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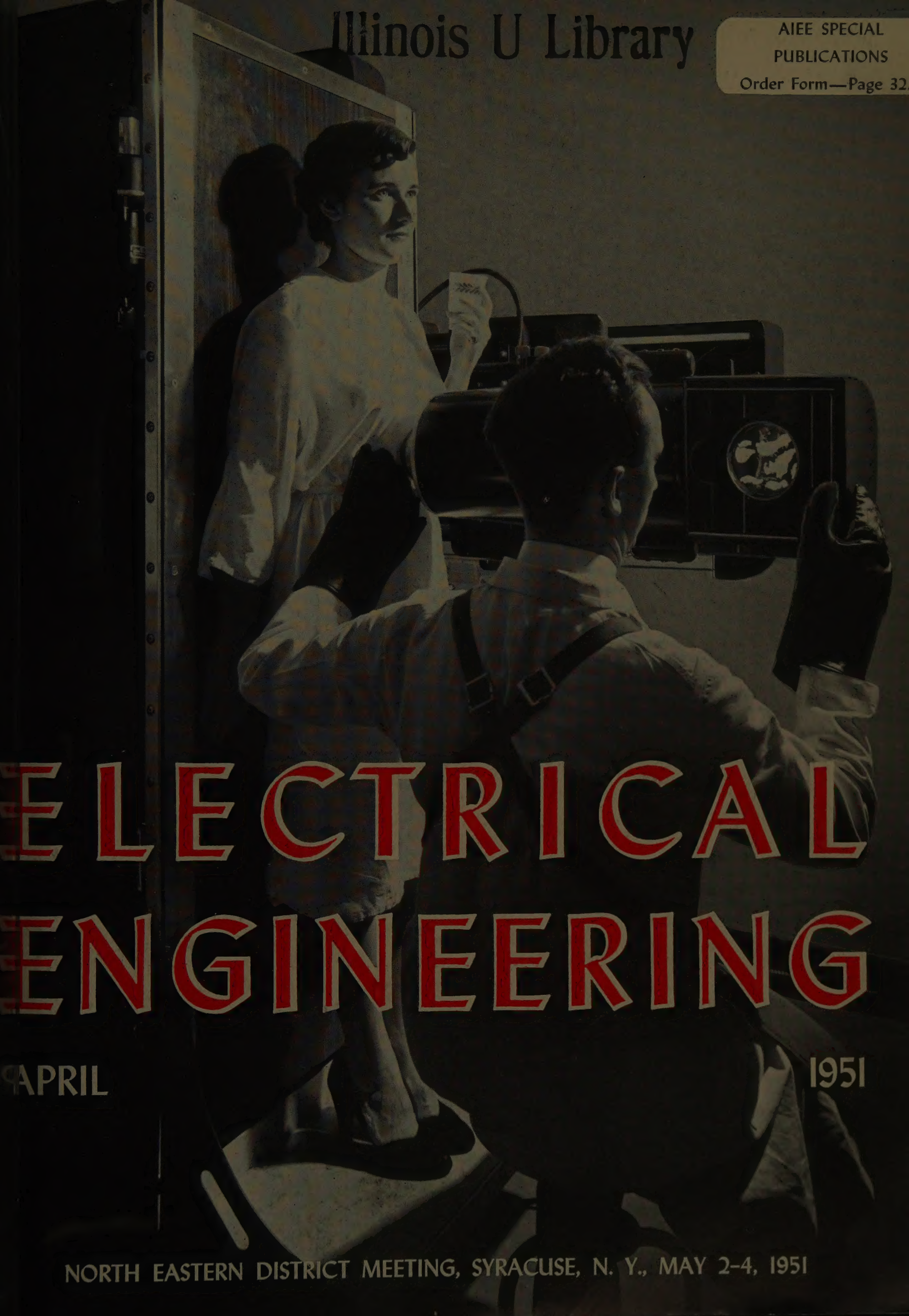

ELECTRICAL ENGINEERING

APRIL 1951

NORTH EASTERN DISTRICT MEETING, SYRACUSE, N. Y., MAY 2-4, 1951

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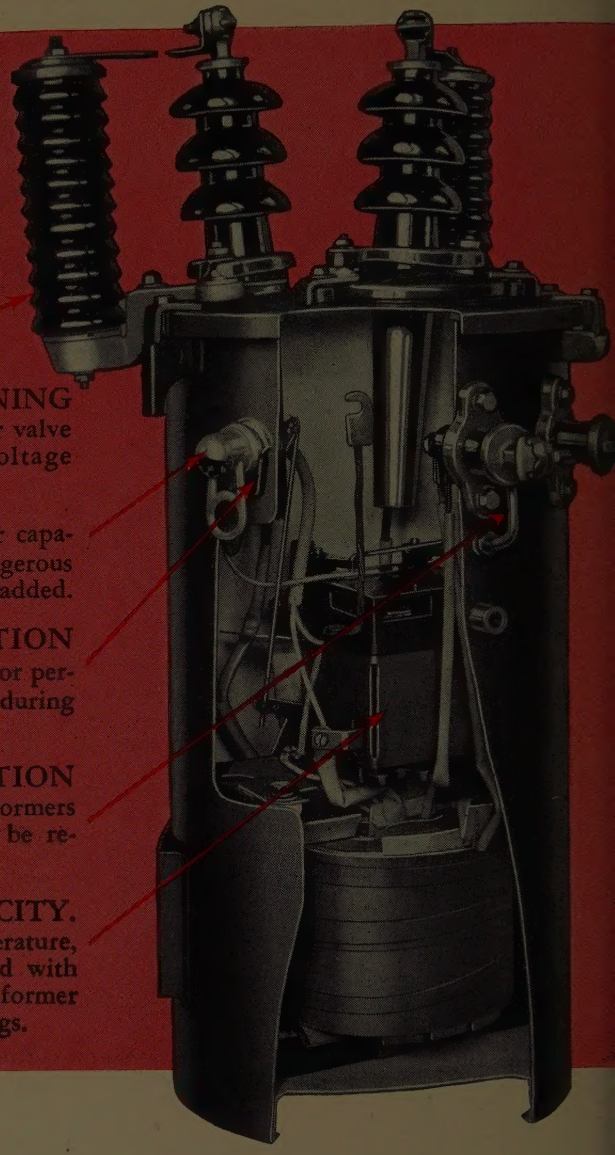

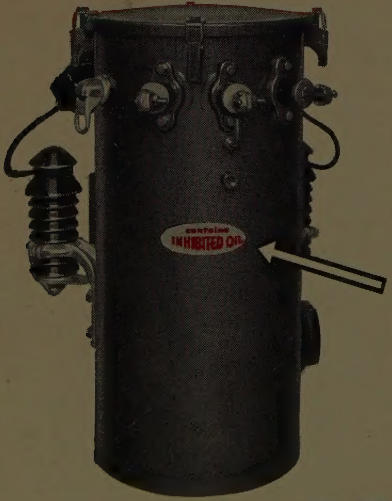

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The Cover: The cover picture shows the Fluoricon, an X-ray fluorescent image amplifier, in one of its experimental forms. The Fluoricon has a brightness amplification of slightly over 100 times; thus, detail invisible with the conventional fluoroscopic screen is readily demonstrated with the Fluoricon. See story on pages 292–96.

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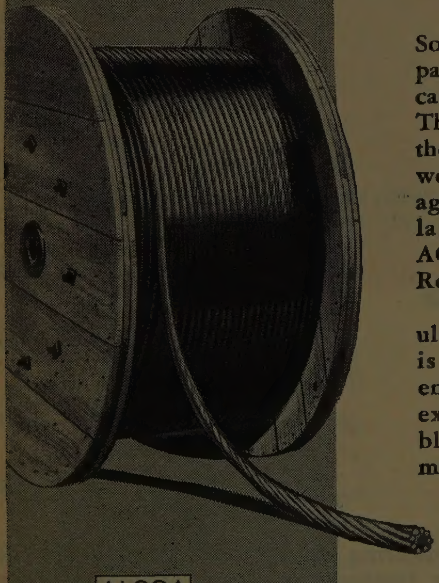
(Photo courtesy Southern California Edison

Imagineering Anniversary on Big Creek . . .



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HIGHLIGHTS........

Instrumentation in Civil Defense. At the present time there are no radiation detection instruments on the market which fulfill all the requirements put forth in tentative specifications by the Federal Civil Defense Administration. It is also true that there is no need for each civilian to have some type of radiation detector. It is recommended that radiological monitoring be left to trained Civil Defense teams in order to make the best use of the available instruments (*pages 287–90*).

Power Generation. A summary of electric power generation and its relation to industrial applications has been compiled by Kennard Pinder, chairman of the AIEE Committee on General Industry Applications. The summary covers types of generation, uses of power, costs, and numbers of consumers (*page 291*).

Intensification of X-Ray Images. By the use of a new method of amplifying X-ray images, these signals can be transmitted by television or used as the subject of motion pictures. The signals may be used for both teaching and diagnosis. With the increased brightness and contrast available the X-ray technique will be a greater aid to diagnosis (*pages 292–96*).

Centralized Control Boards. A discussion of the advantages of using centralized control for steam-electric generating plants is presented this month. New designs of such control boards make them compact and safe, and they offer a saving in operating personnel (*pages 304–07*).

An Immoderate View of Engineering Education. A serious discussion on the conflict between a liberal engineering education and a more technical specialized one is given a witty presentation by Walter LaPierre of Columbia University. The defects of the lecture method, problems of adjustment for the new graduate, and two concepts of the electrical engineer are treated in the article (*pages 299–303*).

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Ultraviolet Equipment. Until a few years ago ultraviolet radiation was used almost exclusively by the medical profession, but now it is finding wide use in industry. It has been used to prevent contamination of drugs in pharmaceutical plants, to sterilize blood plasma and vaccines, and to furnish light for photochemical processes (*pages 307–10*).

Railroad Control System. In the modern cab signaling and train control system discussed this month, the engine-carried apparatus is inductively linked and selectively responsive to coded alternating current in the running rails. The frequency of coding determines the cab signal indication displayed and is dependent upon traffic conditions ahead of the train. Absence of rail current or the presence of uncoded current establishes the most restrictive speed control conditions (*pages 311–17*).

Electric Power in the Petroleum Industry. A study has been made of the use of electric power in drilling, producing, transporting, and refining petroleum products. The phase of the oil industry most susceptible to future electrification is disclosed; this disclosure can be used by utility management to guide its promotional efforts (*pages 319–23*).

Confinement of Transformer Noise. To relieve complaints of transformer noise in a residential neighborhood the Pacific Power and Light Company studied this problem and its possible solutions. The effects and costs of temporary drapes and barricades, permanent sound-confining enclosures, and more quiet transformers were observed in this research (*pages 325–30*).

Generalized Electrical Formulas. There has always been confusion regarding the various unit systems used in the calculation of electrical quantities. A set of generalized formulas for determining these quantities has been developed and is presented this month (*pages 332–36*).

Frequency-Modulated Telegraph Network. With one exception, the carrier telegraph systems of the major record communication companies of the world are operated by the amplitude-modulated method. That exception is the trunk-line and tributary network of Western Union Telegraph Company which, while realizing excellent spectrum economy, employs frequency modulation (*pages 338–42*).

Interexchange Tandem Trunking. The factors affecting the general problem of interexchange trunking which have led to the development of the present tandem network in the Los Angeles Metropolitan Area are reviewed this month. The major elements of a system which now employs a total of five tandem switching units, three of which are cross bar tandem offices, are described (*pages 344–49*).

Electrical Essays. The sixth in a series on Motionally Induced Electric Fields by J. Slepian, and two short articles by A. A. Kroneberg, make the electrical essays this month very interesting (*pages 350–54*).

AIEE Proceedings

Order forms for current AIEE *Proceedings* have been published in *Electrical Engineering* as listed below. Each section of AIEE *Proceedings* contains the full, formal text of a technical program paper, including discussion, if any, as it will appear in the annual volume of AIEE *Transactions.*

AIEE *Proceedings* are an interim membership service, issued in accordance with the revised publication policy that became effective January 1947 (*EE, Dec '46, pp 567–8; Jan '47, pp 82–3*). They are available to AIEE Student members, Associates, Members, and Fellows only.

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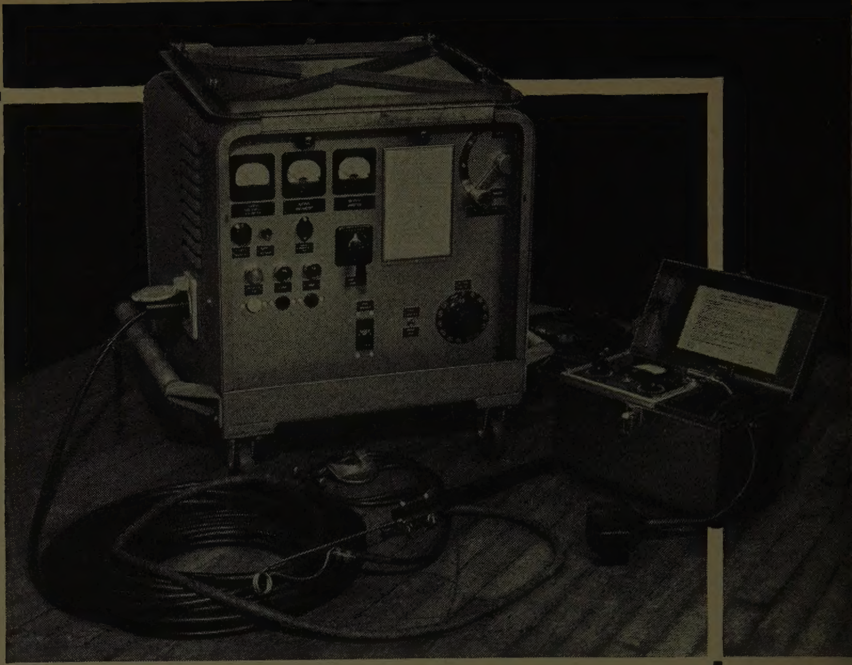

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Instrumentation in Civil Defense

R. L. BUTENHOFF

Radiological hazards after an atomic bomb explosion vary according to whether it is an air burst, water burst, or ground burst. The Federal Civil Defense Administration has tentative specifications for different radiation-detection instruments. A warning is given to prospective instrument buyers regarding instruments they might buy for personal use in civil defense.

CIVIL DEFENSE planning is a popular subject in this present day
d age. Probably the reason
r this is because it is a sub-
ct that concerns each and
ery one of us, and many
estions have been asked and
any criticisms offered. Un-
rtunately, too many people
isinterpret civil defense as being synonymous with the de-
nse against atomic weapons and, in particular, the defense
ainst nuclear radiations, and they are quite concerned
out the answer to such questions as: "How can I detect
is radiation?" "How will I know when I am receiving
?" "How can I protect myself from it?" It should be
inted out that this business of detecting radiation, or
hat is commonly called radiological monitoring, is only a
ry small part of the over-all problem that presently con-
onts the Federal Civil Defense Administration (FDCA),
ate, and local civil defense authorities. The civil-defense
anners can draw on much civil-defense experience,
cumulated by Great Britain and other European coun-
ies, regarding the fire and blast effects of bombs, but little
formation, aside from that obtained in Japan, is available
ncerning the possible radiation hazards which might
sult from atomic weapons and their bearing on civil de-
nse. This fear of the unknown has lead many people to
ace far too much emphasis on the atomic bomb and the
diation released. Some local civil-defense organizations
ve become bogged down because of their great concern
er these radiation problems when they should be follow-
g the indicated paths toward the improvement and dis-
rsal of their fire-fighting, police, and medical facilities.

It is not the intention to imply that serious radiation
zards may not be encountered; it is felt, however, that
ese hazards will be secondary to the primary damage
used by blast and thermal radiation. The explosive
fects of an atomic bomb burst are essentially the same as
ould be caused by an equivalent burst of TNT. How-
er, the atomic bomb releases a greater amount of heat and also produces a vast quantity of ionizing radiation which is highly penetrating and damaging to living organisms so, naturally, some consideration must be given to the effects of nuclear radiation. For a better understanding of this problem, these probable radiation effects on humans are summarized in Table I of this article.

ble I. **Probable Early Effects of Acute Radiation Doses over Whole Body**[1]

ute Dose, entgens	Probable Effect
25	No obvious injury
-50	Possible changes but no serious injury
-100	Blood-cell changes, some injury, no disability
)-200	Injury, possible disability
)-400	Injury and disability certain, death possible
)	Fatal to 50 per cent
) or more	Usually fatal

A summary of possible radiological hazards which might be encountered under different conditions will follow. An atomic bomb may be exploded in three ways—as an air burst, water burst, or as a ground burst.

AIR BURST

THE AIR BURST is the most probable way atomic weapons may be employed since maximum destruction to ground installations is achieved by a bomb exploded at a predetermined height—usually a few thousand feet. With an air burst two sources of radiation result: that occurring during the explosion, called the initial or prompt radiation, and that remaining after the burst, called the residual radiation. The gamma exposure one might receive from prompt radiation at various distances from the epicenter of a Nagasaki-type bomb explosion is shown in Figure 1. This is primarily gamma and high-energy neutron radiation.

Most of the radioactivity produced in an air burst will be dispersed into the upper atmosphere and little residual radiation will remain on the ground. What fission products do remain will decay very rapidly according to the expression: $R_2 - R_1 t^{-1.2}$, where R_1 is the initial radiation level; R_2 is radiation level at time t after the first reading was taken; and t is the time between readings. Assuming that the radiation level within an area is one roentgen per hour one hour after the explosion, the dosage rate as a function of time will be as shown in Figure 2. This residual radiation will be beta and gamma plus a small amount of alpha, assuming the bomb is reasonably efficient.

WATER BURST

AN UNDERWATER BURST producing a base surge may spread a great deal of radioactive contamination, particularly in the down-wind direction from the explosion. Large amounts of radioactive materials may be produced in the water and would make it hazardous to use. The area of structural damage produced will be limited to a small area surrounding the burst, as most of the energy is dissipated in

---

Full text of a conference paper presented at the AIEE Winter General Meeting, New York, N. Y., January 22-26, 1951.

R. L. Butenhoff is chief, Radiation Instruments Branch, Division of Biology and Medicine, United States Atomic Energy Commission, Washington, D. C.

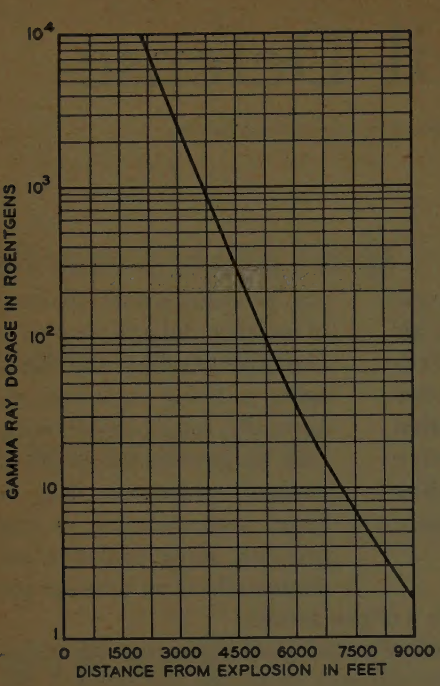


Figure 1. Total dosage of initial gamma radiation as function of distance from explosion (reprinted from reference 1, page 235)

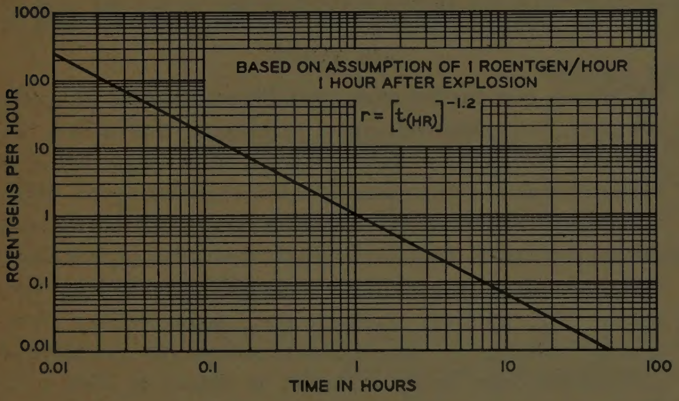


Figure 2. Dosage rate as function of time, assuming one roentgen per hour at one hour after explosion (reprinted from reference 1, page 253)

producing steam and pushing aside the water. The prompt radiation from the explosion should not be too serious, and it is then the residual radiation for which there should be concern. This is primarily beta and gamma in nature.

GROUND BURST

An atomic bomb exploded at a very low altitude, that is, a few hundred feet, on the ground or under the ground, would create only a small area of contamination but that would be highly radioactive. This area of contamination may be only a few blocks in diameter. The area of structural damage produced would be small in comparison to an air burst, as the earth would absorb much of the energy and a large percentage of that remaining would be dissipated upwards. Persons near enough to the explosion to receive a lethal dose of radiation would probably be killed anyway by the effects of blast or the intense heat of the flash. A considerable amount of radioactive dust might be produced which could fall out over a large area but would probably not cause very many casualties. The residual
radiation in the crater would be alpha, beta, and gam

To summarize this matter of possible radiological
ards, it appears reasonable to assume that an enemy w
use the atomic bomb in the most effective way, w
would mean an air burst. With an air burst the ra
logical problems are not too serious and it would ap
that radiation detection instruments are not as wi
needed in civil-defense operations as some people
previously suspected. However, the FCDA feels that c
defense groups must prepare for any eventuality and r
be ready to monitor the fall-out from radioactive cl
and the areas that become contaminated as the resu
bombs which do not explode completely or which are
onated deliberately at low levels or under water.

The Federal Civil Defense Administration believes
instruments described in the following paragraphs wi
required by civil defense organizations. The use of t
instruments is also given. The instrumentation requ
for civil defense use would appear to fall into three cla
(1) Radiological Monitoring Instruments; (2) Perso
Accumulated Dosage Meters; and (3) Laboratory Eq
ment for Specialist Teams.

RADIATION MONITORING INSTRUMENTS

These instruments would be used by monitoring te
which, under the present Federal Civil Defense
ministration plans, will be established on a local b
The function of these teams is twofold: area surveying
service monitoring. Teams assigned to area-survey
would locate and determine the boundaries of areas tha
dangerously contaminated. Teams assigned to se
monitoring would be attached to police, fire, rescue,
other civil-defense services and would advise people w
these services regarding the hazard of entering areas tha
radiologically "hot." It is planned that essentially a
the instruments used by these monitoring teams will be h
intensity gamma survey instruments covering a range
approximately 0.025 to 500 roentgens per hour. Tent
specifications for such an instrument have been prepare
the FCDA and copies may be obtained from them
request.

Briefly, these tentative specifications call for an in
ment that is small, lightweight, and rugged which ca
used by relatively inexperienced personnel to mea
gamma dosage rates. The instrument should provide ea
operation and maximum operating life, and should rec
a minimum of maintenance. It may be a Geiger-cou
instrument, ionization chamber, scintillation counte
any other sensing device capable of responding to ga
radiation over an intensity range of 0.025 to 500 roent
per hour. The accuracy of a response to a gamma
ation dosage rate should be within ±30 per cent.
required accuracy considers spectral dependence, r
accuracy, temperature dependence, hysteresis effects,
so forth. The use of only four size-*D* flashlight-type
teries is recommended. At the present time, no in
ments are in production which entirely meet these t
tive specifications. However, several instruments
under development which show considerable promise.

Examples of some of the instruments which have bee loped with application for civil defense in mind, but iich were developed prior to the existence of the FCDA ecifications, are shown in Figure 3. None of these instruents comply with all of the requirements of FCDA's ntative specifications and are shown primarily to acquaint e reader with some of the instrumentation techniques iich might be employed in a civil-defense instrument.

Instruments *A* and *B* in Figure 3 employ halogen-filled eiger tubes and are capable of measuring gamma radiion dosage rates up to 500 roentgens per hour. The curnt from the Geiger tubes is measured directly without rther amplification. The current output as a function of mma dosage rate for two typical tubes is shown in Figure Instrument *A* was developed for the Naval Bureau of iips and instrument *B* was developed by the New York perations Office of the Atomic Energy Commission. The rcuit of instrument *B* is shown in Figure 5. Informan on the operation of these instruments is available.[2]

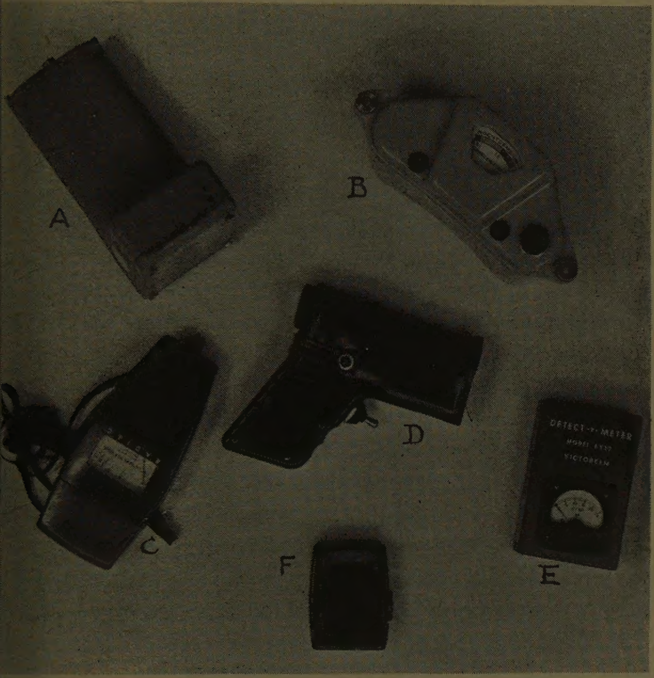


Figure 3. Examples of simplified instruments

Instruments *C*, *D*, and *E* in Figure 3 are ionization chamr instruments employing simple electrometer-tube ciris with meter indication. Instrument *F* is an electroatically charged electrometer. The rate of discharge is rectly proportional to the dosage rate and may be deterined with a stop watch, or roughly, by counting off the conds it takes to discharge.

PERSONNEL ACCUMULATED DOSAGE METERS

NSTRUMENTS which measure the accumulated dosage received by persons are commonly called dosimeters. osimeters which might be required by civil-defense oups may be divided into two classes: those which the iter feels may be worn by individuals in areas subject to omic attack, and dosage meters worn by civil-defense rsonnel who work in radiologically contaminated areas.

The first type of dosimeter would measure ranges up to a lethal dose. The need for dosimeters of this type, however, has not been determined. Their purpose would be to aid medical persons at treatment centers in segregating the patients into groups according to the exposures they had received. There are, at present, some who question the advisability of employing dosimeters for segregation purposes. Many doctors feel that the patient should be treated according to his symptoms and that these symptoms are the best indication of the biological damage which might have been produced in the individual by radiation.

The second type of dosimeter would be worn by civil-defense workers and by the radiation-monitoring team members and would indicate the dosage these people received from the residual radiation as they went about their duties. These dosimeters should probably have a range in the order of 100 roentgens.

Figure 4 (right). Measured current from high- and low-sensitivity Geiger tubes as a function of gamma dosage rate

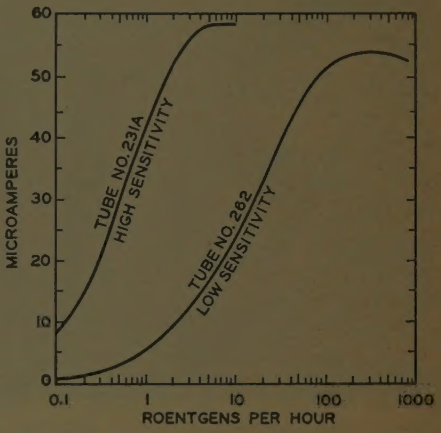
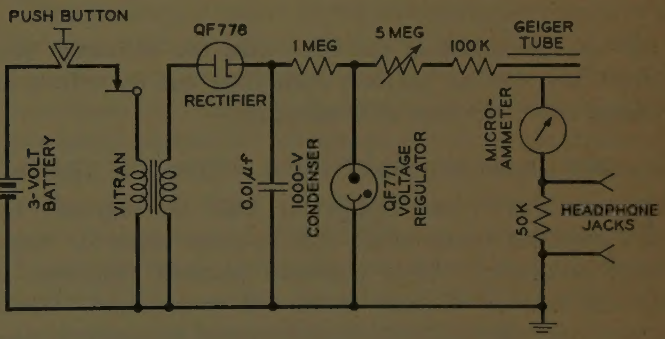


Figure 5 (below). Circuit diagram of Geiger counter tube instrument



Tentative specifications have not as yet been released for dosimeters by the FCDA. Several dosimeters which are being developed or which are presently in use are shown in Figure 6. Type *A* is a photographic film dosimeter using X-ray dental-size film of the type generally used throughout atomic energy laboratories. The darkening of the film caused by exposure to radiation is measured with a densitometer. Type *B* is a chemical dosimeter using chloroform and water containing a *p*H-sensitive dye. The free chlorine produced by the interaction of radiation with the chloroform forms acid which changes the *p*H of the water and turns the color from purple to yellow. The *p*H of the water layer can be so adjusted that the color will change at predetermined dosages, for example, 200, 400, 600, and 800 roentgens. This type of dosimeter was developed by the Atomic Energy Project at the University of California at Los Angeles.

A quartz-fiber dosimeter using a quartz-fiber electrometer developed by Argonne National Laboratory is shown as *C*. The position of the fiber is viewed through an optical system and thus the discharge of the charged electrometer system is determined. Type *D* is a pocket ionization chamber, sometimes called a pencil meter, which is simply a very-well-insulated air capacitor which is charged to a given voltage at the beginning of a working day. Radiation passing through the chamber will discharge it, and the charge lost will be a direct function of the radiation dosage which has been received.

Type *E* is a self-developing-type photographic film dosimeter developed through the Signal Corps. The darkening of the central film strips is measured by comparison with a precalibrated series of standards which are self-enclosed and also are developed at the same time the dosimeter film strips are, thereby partially cancelling out the effects of temperature and time of development.

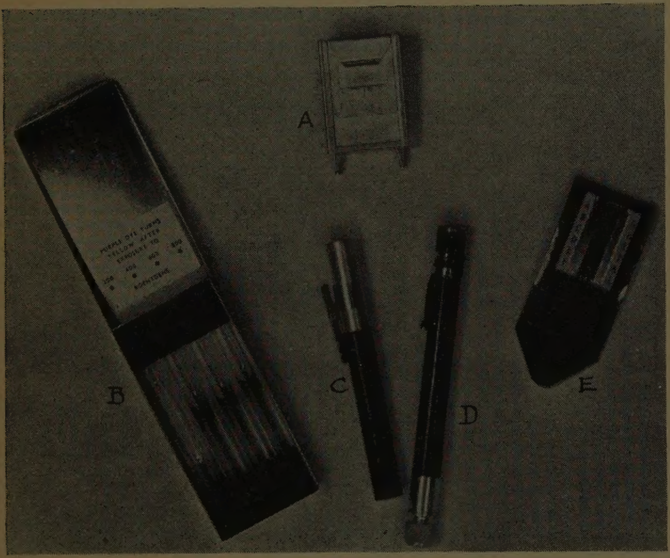


Figure 6. Examples of types of dosimeters

LABORATORY EQUIPMENT FOR SPECIALIST TEAMS

LABORATORY-TYPE equipment will be required by specialist teams which will examine areas for long-time occupancy. It is presently planned that only a limited number of these teams will be required. Their equipment will consist of such instruments as counter scalers for use with special alpha, beta, and gamma detectors, low-intensity beta-gamma survey meters, alpha-proportional counters, air samplers, and such equipment needed to determine the radiochemical nature of samples brought in from contaminated areas. Instruments of this type are presently available and little, if any, development work should be required to adapt them to civil-defense uses.

Those readers who wish to try their hand at developing instruments for civil-defense purposes should acquaint themselves with the civil-defense radiological problems reading the following booklets:

United States Civil Defense. National Security sources Board (NSRB), *Document 128,* price $0.25.

United States Civil Defense, Health Services and Spe Weapons Defense. FCDA *Document AG-11-1,* price $0.

Survival Under Atomic Attack. NSRB *Document* price $0.10.

The Effects of Atomic Weapons, price $1.25 (pa bound).

These booklets may be obtained for the price indica from the Superintendent of Documents, United Sta Government Printing Office, Washington 25, D. C. T FCDA's pamphlet, "Civil Defense Radiological Monitor Instruments Specifications," may be obtained free charge from the Federal Civil Defense Administrati Executive Office of the President, Washington, D. C. instruments developed in accordance with these specifi tions or in any way thought applicable for civil-defe purposes should be brought to the attention of the FC

WARNING

FOR THOSE readers who may be thinking they would radiation instruments for their own personal use note of warning should be sounded. At the first regu meeting of the AIEE-Institute of Radio Engineers S committee on Nuclear Instruments in New York on Janu 23, 1951, it was thought advisable to emphasize to American people that extreme caution should be exerci in procuring instruments for civil defense. Unintenti ally, some companies may take advantage of the aver person's fear of radiation and may sell instruments to public which are unessential and in reality are next worthless for civil-defense purposes. In general, howe the instrument companies which are well established in industry have cautiously refrained from selling instrum to the public for personal use, even though they realize they could probably sell any device they chose to manu ture, from a gold-leaf electroscope to a crude Geiger co ter. These companies prefer to maintain the good repu tion they have acquired through the years, and man them presently are developing instruments in accorda with the FCDA's specifications.

The people of this country should thoroughly acqu themselves with the broad aspects of civil defense and sho bring themselves to the realization that radiological struments are not required by each and every person. avoid paying money for worthless devices, only instrum which are recommended by the Civil Defense agen should be considered for purchase. The purchase of presently existing radiation instrument is inadvisable u these instruments are approved for civil defense, as purchases may be of little help to the individual and constitute a serious drain on the resources of the countr

REFERENCES

1. The Effects of Atomic Weapons. United States Government Printing Washington, D. C., 1950.

2. Geiger Counter for Civilian Defense Use, H. D. Le Vine, H. J. DiGiovanni, Coe. *Nucleonics* (New York, N. Y.), volume 6, number 6, June 1950, pages

Electric Power Generation

Its Relation to Industrial Applications

KENNARD PINDER
FELLOW AIEE

A study has been made of the industrial applications of electrical power generation. It was found that of the total 344,400,000,000 kilowatt hours of power generated in 1949 in the United States, 84.3 per cent was generated by utilities and Government authorities and 15.7 per cent was generated by industrial plants.

IN INDUSTRY, electric power has grown to be the most important form of power. It has been said that the nation which puts in the hands of its people the most bundant supply of electricity will have the highest standard f living.

Some interesting figures in connection with electric power peration and its use in industry are tabulated here.

Public Utility, Municipal, and United States Authorities

. **Electric power generation**	**Billions of Kwh**	
	1948	**1949**
Power generated	282.7	290.4
Power generated in fuel plants	200.2	200.9
Power generated in hydro plants	82.5	89.5
Percentage of hydro to total generation	29.2	30.8

. **Installed Capacity** (with reference to A)	**Millions of Kw**	
Generating capacity	56.56	61.17
Fuel plants	40.91	44.78
Hydro plants (including Grand Coulee)	15.65	16.39
(Grand Coulee)	0.992	1.316

. **Revenue from energy sales**	**Millions of Dollars**	
	4,313.4	4,611.0

. **Number of Utility Customers**	**Millions**	
Residential	33,550	35,350
Rural	1,690	1,820
Commercial and industrial	5,340	5,520
Small—5,132 Large—208		
Municipal, railroad, and miscellaneous	142	149
Total	40,722	42,839

. **Summary of Utilities and Government Authorities**

1,607 Utilities and Government Authorities	
Number of plants	3,910
Total capacity in kilowatt hours	61,166,300
Steam Power	
Number of plants	1,050
Capacity in kilowatt hours	43,043,400
Water Power	
Number of plants	1,471
Capacity in kilowatt hours	16,341,600
Internal Combustion Engines	
Number of plants	1,389
Capacity in kilowatt hours	1,731,300

II. Industrial Power

	Billions of Kwh	
Purchased by industries	117.6	123.0
Generated by industries (estimated)	53.7	54.0
Sold by industries	5.5	5.5
Total used by industry	165.8	171.5

III. Total Power Generated in the United States

	Billions of Kwh	
Generated by utilities and Government authorities	282.7	290.4
Generated by industries	53.7	54.0
Total generated	336.4	344.4
Estimated internal uses and losses	43.0	44.2
Total power used	293.4	300.2

Of the 171.5 billions of kilowatt hours of electric power used by industry in 1949, about 75 to 80 per cent of this amount was used by motors; the balance was utilized by electric furnaces, electrochemical operations, and lighting.

It is estimated that 100,000,000 horsepower of motors is installed in industrial applications. This total does not include the additional horsepower of many millions of motors used with appliances nor that in the fast-growing number of motors used on the farms and for air conditioning, elevators, and other services in city buildings and for transportation.

Since there are about 12,000,000 production workers in industry, each one of them has available approximately 8 horsepower of motor power, and he uses over 10,000 kilowatt hours per year. Because the muscular power of a man is scarcely more than 1/10 horsepower, the available motors multiply the power of the average American industrial worker some 80 times. Electricity now performs the work equivalent to that of 1,000,000,000 men in industrial plants. Today, the supply of machine power back of the American worker is $4^1/_4$ times, on the average, what it was in 1900, and production has doubled in terms of output per hour of work.

By any measuring stick, the answer is the same: In the first half of the 20th century, the United States became the richest and most productive country in the history of civilization. The electrification of the industrial machine was a principal contributor to this great achievement. This large amount of power per worker is one of the secrets of our industrial production.

Kennard Pinder is with E. I. du Pont de Nemours and Company, Wilmington, Del.

The Intensification of X-Ray Fluorescent Images

W. S. LUSBY

A PAPER ENTITLED "Fluoroscopes and Fluoroscopy,"[1] which has become a classic of our time, was presented by Dr. W. Edward Chamberlain, professor of radiology at the Temple University Medical School in Philadelphia, as the Carmen Lecture of the Radiological Society of North America in San Francisco in December 1941. Doctor Chamberlain concluded his essay with an appeal for the development of a fluoroscopic image amplifier of sufficient brightness intensification to overcome the major limitations of X-ray fluoroscopic procedures. The level of brightness in conventional fluoroscopy was then and is today so low that even with maximum dark adaptation and examining an abdomen the eye has an acuity nearly two orders of magnitude poorer than the acuity of the eye at the level of brightness used for reading radiographs.

The work I will describe in this article is the work of others over many years and is not presented as a personal accomplishment.[2] Figure 1, taken from Doctor Chamberlain's paper and based on measurements by S. Hecht,[3] shows the variation in visual acuity with brightness. Note the comparison between fluoroscopic levels and radiographic reading levels of brightness. The eye can see a 1/1,000-inch separation in good light but only approximately 1/32 inch at fluoroscopic levels with the extreme case requiring 1/4-inch separation to be seen. All data are for the dark-adapted eye and 100-per cent contrast. Separation required for perception increases as contrast is reduced.

Two experimental models of devices for the intensification of X-ray fluorescent images were put into use in September 1950. These devices have a brightness amplification slightly over 100 times and enable detection of a 3-per cent thickness difference.

Figure 2 illustrates a typical conventional fluoroscope. Thousands of these are giving valuable service to doctors today.

Considerations of patient safety prohibit an increase in the intensity of the X-ray beam. The amplification of the signal must come after the X-ray beam has passed through the patient.

Doctor Chamberlain said in part, ". . . when [a 1,000-fold amplification] comes it will put medicine and radiology through another revolution, not very different from that which followed the advent of roentgenography and present-day fluoroscopy at the turn of the century" and "perhaps what is needed is a realization by the physicists and engineers of the great need for brighter fluoroscopic image and the great advantage to humanity their arrival woul entail."

EARLY EXPERIMENTS

A SMALL GROUP of men then in Baltimore, Md., includin Dr. J. A. Hutcheson, Walter Evans, H. D. Moreland and C. S. Eason, were led by this appeal to sponsor th undertaking of this development by the Westinghous Company at their East Pittsburgh Research Laboratorie

Today a working image amplifier is a reality. Experimental models are undergoing clinical evaluation.

The first, or study, phase of the development was carrie out by the late Dr. R. C. Mason of Pittsburgh. In a unpublished paper written at the outset of the work D Mason presented the results of his theoretical studies of th problems of intensification of X-ray fluorescent images an presented his calculations o a question which he foun might affect the usefulness o such a device—the fluctuations in brightness, produce as a result of the discrete an random nature of the X ray falling on the screen. At th level of brightness available i conventional fluoroscopy thes fluctuations are present but not noticeable because of th inability of the eye to discern them at such low levels o brightness. As recently as September 1948 an article wa published by a leading American scientist in a prominen technical magazine intending to prove that image intensification cannot be useful because of this limitation.

The first image amplifier experimental work of D John W. Coltman attacked this problem of scintillatio limitation. Shortly thereafter Doctor Coltman set up apparatus for producing on a cathode-ray oscilloscope a 1-square centimeter image composed of randomly distributed fin dots, and by viewing through a 10-to-1 reducing optica system it had a 1-millimeter-square field illuminated b populations of dots corresponding to the number of X-ra photons absorbed in producing the conventional X-ra fluoroscopic images.

Means for introducing into the image a pattern co sisting of a band of variable, but known, width and contra was provided. Similar image patterns except with unifor illumination were provided. Ability of six subjects to se the patterns was carefully studied. The conclusio reached was that even with populations of scintillation corresponding to the lower end of the usual range

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Full text of a conference paper presented at the AIEE Winter General Meeting, New York, N. Y., January 22–26, 1951.

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fluoroscopic brightness, but with brightening of the image of the order of 10,000 times, the degradation of the readability of the image was less than 50 per cent.

It is desirable, of course, that the fullest possible use of X-ray photons should be made to minimize deterioration of readability.

As a result of these experiments it was concluded that a successful image brightener would be useful, and development was continued, probing for the plan which seemed to offer the most advantages.

The building blocks of the designs were investigated one by one to find the possibilities and limitations of each. Pilot tubes of simple design one inch in diameter were made by the dozens.

PRESENT FORM OF THE FLUORICON

By THE SUMMER of 1949 Doctor Coltman and his associates had succeeded in producing a practical working image amplifier. Figure 3 shows the principle of operation of the Fluoricon, as it has been named, which is essentially a highly evacuated bottle approximately 17 inches long. X rays leaving the patient or casting come through the large glass end and impinge on the fluorescent screen. This phosphor is similar to conventional fluoroscopic screens, being zinc sulphide. The diameter of the screen is approximately six inches of which the central 5-inch-diameter area is used. X rays are converted to visible light with approximately 7,500 light photons for every X-ray photon absorbed. The light photons eject electrons from the cesium antimony photosurface which is close to the phosphor, yielding approximately 450 electrons for each original X-ray photon absorbed. These electrons move down the tube under the influence of accelerating electrostatic field.

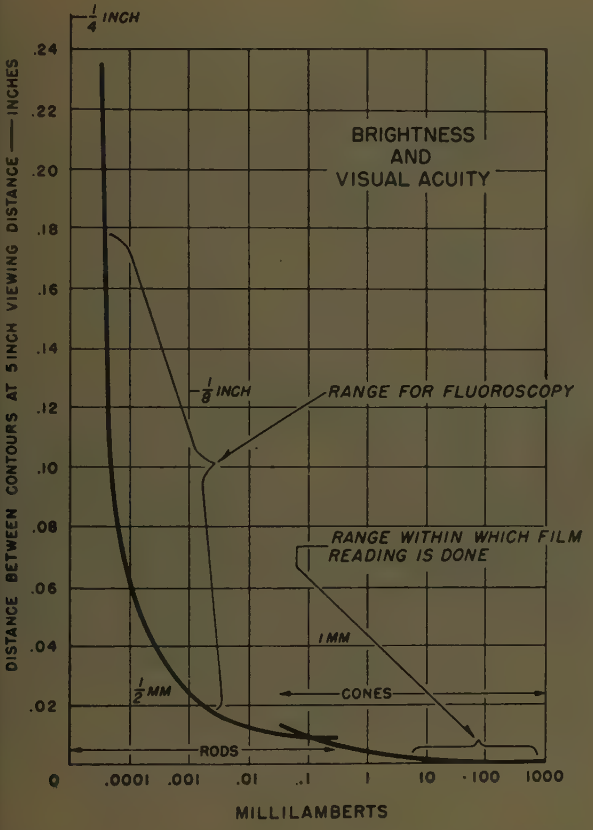


Figure 1. Variation in visual acuity with brightness

As the electrons leave the phosphor-photosurface cathode, there is an aerial electron image five inches or more in diameter varying in electron density in accordance with the subject density in the X-ray beam. The main accelerating potential is approximately 30 kv. Most of this voltage appears across the main electrostatic lens near the anode. Four field-shaping weak lenses have smaller voltages. The electrons forming the image are sharply refocused on the anode which has a very fine grain zinc-cadmium sulphide phosphor backed by a thin aluminum foil. This foil prevents light from feeding back to the cathode phosphor. It also maintains the phosphor at the desired potential and reflects light out. The phosphor emits light of a color closely matching the maximum sensitivity of cone vision. The anode image is one inch in diameter and inverted.

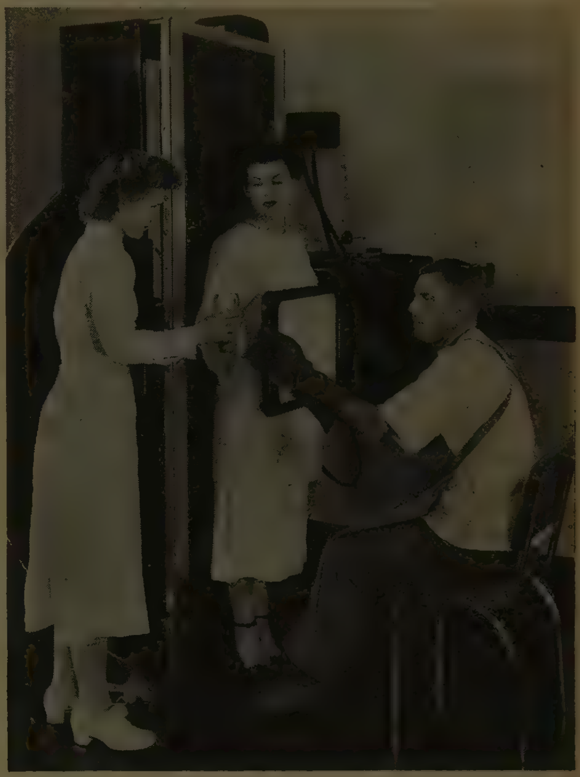


Figure 2. Typical conventional fluoroscope

True amplification occurs when energy from an external source is supplied to accelerate the electron image. A substantial part of the amplification, a factor of 25, occurs from delivering all of the energy of the accelerated electrons to a 1-inch circle instead of to a 5-inch circle, thus concentrating the energy and producing more light per unit area at the phosphor.

Remarkably, it is possible by means of a properly chosen optical system to view this output image with five times' magnification without loss of brightness. In the terminology of optics, the exit pupil of the magnifying system must be kept larger than the pupil of the eye if no brightness is to be lost. Figure 4 shows a cutaway and exploded sketch of one type of optical system. This type provides good freedom of head position to the observer, properly reinverts the image, and gives magnification of approximately three times. Other types of optical system give a magnification of five, restoring the original size.

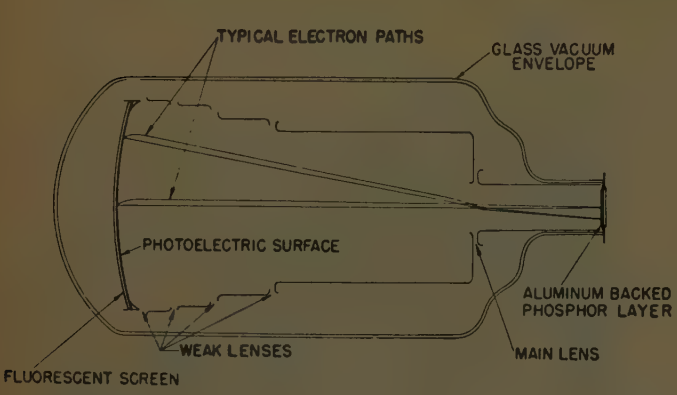


Figure 3. Principles used in the operation of the Fluoricon

It will be obvious immediately that many special techniques had to be developed to make a tube of this type possible. Fundamentally the phosphor is not compatible with cesium. The cesium is not an ideal tenant for a high-vacuum high-voltage device. Ingenious mechanisms are used in the process of coating a uniform photosurface on the cathode. Most of the research work over the past few years has been development and perfection of processes and techniques for improving the over-all quality of the Fluoricon and achieving consistent quality in production. For the past two years the work has been under the direction of Dr. Fitz-Hugh B. Marshall. One basic United States patent[4] and two process patents[5,6] have been issued; numerous additional patent applications are filed.

QUALITIES REQUIRED IN FLUORICON

If an image amplifier is to meet the requirement of medical and industrial fluoroscopy, certain qualities have to be built into it.

Although small improvements are avidly sought, the ultimate goal is to make the readability of the fluoroscopic image equal to the readability of the radiographic image. This is no modest goal. Such an accomplishment would swing almost all the advantage to fluoroscopy. A few moments' observation of a moving part would be equivalent to thousands of sequential radiographs. Waiting time to get an answer would be eliminated. Radiography would be reduced to a means of providing a permanent record and a means of "stopping" motions too fast for the human eye to see. Fluoroscopy will never take the place of Micronex radiography used in ballistics where exposure times may be 0.1 microsecond.

Film reading is done at about 30,000 to 30,000,000 times the brightness of fluoroscopy, as shown by Figure 1. This high number makes it interesting to refer to data, reproduced in Figure 5, on the tremendous range of tha amazing instrument, the human eye. It is not surprisin to find that the eye has a logarithmic response to cove this range.

Brightness intensification is wanted, but how much The degradation effect of scintillations limits the amoun of amplification which is useful. More important is th fact that the detail present in the aerial X-ray imag coming up to the screen or film in practical conditions o fluoroscopy or radiography is limited. The definition o the intensifying screens and X-ray film are seldom th limiting factors. This is because the X-ray source has finite area, and also the object of interest is usually wel within a large body, being seldom susceptible to placemen close to the film or screen. This introduces substantia geometric unsharpness. A contour separation of 0.00 inch is the limit of definition under typical conditions We must avoid the fallacy of thinking that if the smalles detail in our image is, for example, 0.01 inch then we ca use only that brightness which brings the acuity of th eye up to the point where it can perceive 0.01 inch. Readability of the image is still increasing beyond this point An increase in brightness of 10,000 times appears to be abou all that is useful. The Coltman Fluoricon is still a lon way from a gain of 10,000, but the overwhelmingly enthusiastic response of radiologists to the improvement wit 100 times amplification leaves no doubt as to the need fo and the substantialness of a gain of even 100.

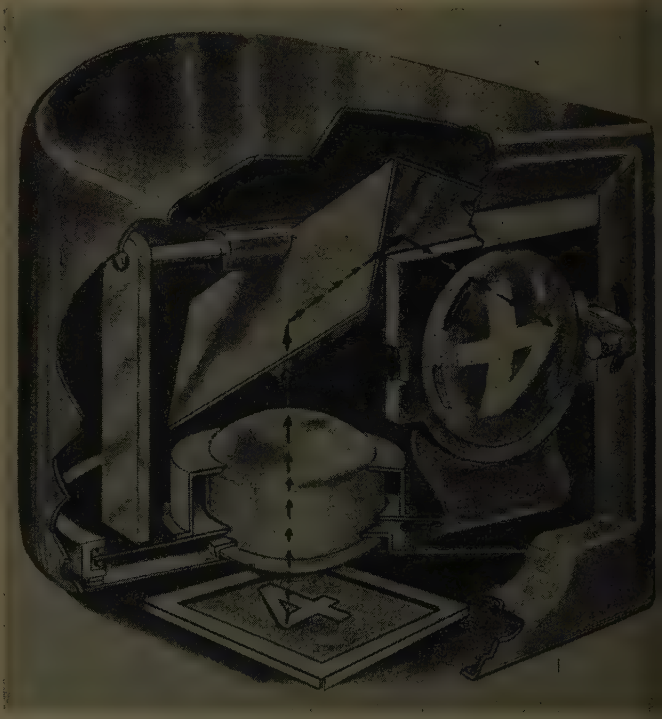


Figure 4. One type of optical system which gives a magnificatio of three times

Of significance is the fact that a gain of 100 times brin the light level of average gastrointestinal fluoroscopy t e point where it will give a signal to an image orthicon ich is substantial compared to beam current noise in e presently available image orthicons.

The second requirement of the Fluoricon is definition. though brightness is needed in order to perceive fine tail, it must not be produced at the expense of definition. o thick a phosphor will reduce definition although it ay increase brightness gain. Definition has been obined in excess of the 0.009-inch contour separation of the pical image. However, it has not been sufficiently excess of 0.009 inch to avoid contributing some effect to e over-all unsharpness.

The output phosphor must have a definition five times at of the input phosphor to contribute an equal amount the over-all unsharpness. The electron optics should oduce a sufficiently flat real image so that its contribution over-all unsharpness is negligible. An interesting ature of the Coltman design is the limitation of initial locity of the photoelectrons from the cathode. By the mbination of narrow bandwidth of visible light energies om the phosphor and high threshold energy of the photoectric surface, the spread of photoelectron initial velocities kept at a minimum. The visible light energy band is aced just sufficiently above the photoelectric threshold get substantial numbers of photoelectrons and yet close ough to it to avoid high initial electron velocities. ence, aberrations in the electron optical focusing which e due to initial spreading of the electrons are held to a inimum.

Contrast is the third requirement. The minimum size a defect visible increases as contrast decreases. There- re, losing image contrast in the device should be avoided. ertain types of lesions such as those of tuberculosis in the ngs present no fine detail but are recognized by the ntrast of a cloud-like area.

Contrast is reduced if we have an over-all background ow or dark current. This is present in defective Fluorins. The production of a high threshold photoelectric rface provides low thermal emission and has minimized rk current. It appears practical to hold dark current a negligible level and under 0.0001 millilambert. It is so necessary to avoid a background glow due to afterglow om the phosphor after prolonged use. Such a glow ould have the same effect as dark current in lowering ntrast and reducing readability. Radiography has an lvantage on contrast since the photographic process n introduce an increase in contrast.

The fourth requirement is the obvious one of uniformity response over the full field of view.

PERFORMANCE OF FLUORICON

XTRAPOLATION of data from idealized conditions of physical testing to practical conditions of clinical use industrial application is not always easy. Some charteristics cannot be reduced to numbers and manipulated th meaning. Therefore, considerable testing of the uoricon has been carried out under a particular set of contions created to simulate a typical problem of gastrotestinal fluoroscopy. Typical X-ray beam intensity and ality, 4 milliamperes at 80 kv, have been used. Eight inches of Prestwood of density and scattering coefficient similar to human tissue is kept in the beam. Test objects being observed have been placed within the Prestwood phantom with 40 per cent of the phantom between the test object and the screen or Fluoricon. X-ray target to skin distance of 18 inches is used. This phantom arrangement gives degradation of readability from both geometric unsharpness and from loss of contrast which is due to X-ray scattering.

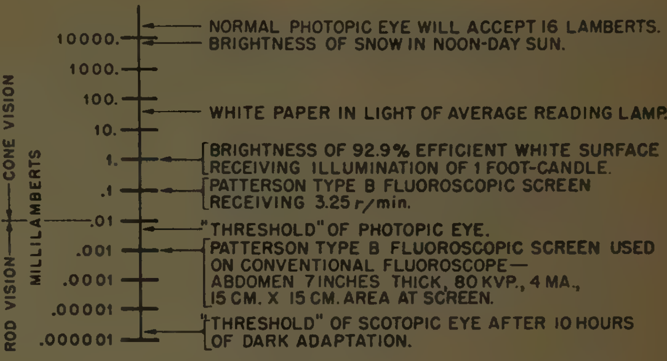


Figure 5. Range of brightness useful to the human eye

In clinical fluoroscopy the lesion or defect is usually of somewhat rounded shape. We can see a square-edged object better but that is not typical of the problem. The radiologist does obtain high contrast, however, by having the patient drink a thick suspension of barium sulphate. Round copper wire was selected as comparable in absorption and a graded series of copper wire screens have been used as test objects. Barium sulphate suspensions will vary in proportion of water used, depending upon the technique of examination used and the preference of the radiologist. In specific cases it may be more absorbing or less absorbing than copper, but copper wire is quite representative of a rounded-contour barium-sulphate-filled defect which is the same size.

When one considers how small a crater in the wall of the stomach, or how small a normal groove or ruga, can be seen in fluoroscopy one notes that as the contour separation goes down the thickness of the barium sulphate in the X-ray beam goes down also and, hence, contrast goes down. This condition is obtained in the test setup because, as the copper wire size becomes smaller, its thickness and, hence, image contrast is reduced. Contrast varies, for example, from approximately 75 per cent for a 15-mesh screen to only 50 per cent for a 50-mesh screen. In the test setup a conventional fluoroscopic wafer grid of lead and wood strips is used to minimize the effect of secondary and scattered radiation. X-ray focal spot size is 0.04 inch (1 millimeter), the finest available which will handle the X-ray tube currents required for fluoroscopy and spot radiography.

Under these conditions, the minimum perceptible mesh size is 50 per cent coarser for the best *B2* conventional fluoroscopic screen than for the Fluoricon. At first thought this is not impressive. It may be put in a different way. Under these conditions the minimum perceptible mesh size is only 70 per cent coarser for the Fluoricon than for radiography. This is with optimum exposure time for maximum readability in radiography.

These data in terms of mesh are

Radiography	50 mesh
Fluoroscopy, Fluoricon	30 mesh
Fluoroscopy, Conventional	20 mesh

Under ideal conditions without all the limitations of the "typical" setup, 55 mesh has been resolved with the Fluoricon.

These data show a much smaller range of minimum perceptible defects considering the light levels of the three techniques of radiography, fluoroscopy with the Fluoricon, and conventional fluoroscopy than one would have predicted from the visual acuity curves taken under idealized conditions.

These data are typical for a Fluoricon with amplification of 100 times. There have been some tubes with amplification in excess of 150, and some data show minimum perceptible mesh size 65 per cent coarser for the *B2* fluoroscopic screen than for the Fluoricon.

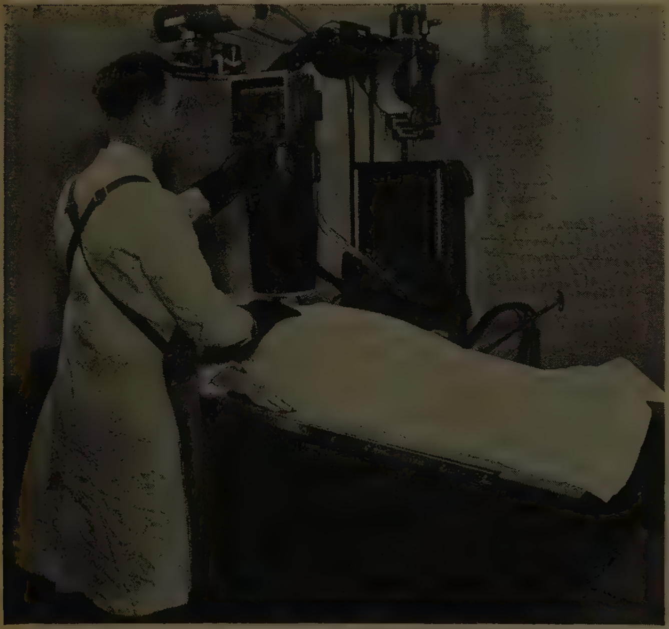


Figure 6. Close-up of the Fluoricon apparatus in use

For typical conditions simulating fluoroscopy of the 8-inch abdomen, visualization of 3-per cent thickness difference is demonstrated.

PRESENT STATUS

AFTER approximately a year of experimental use and testing within the Westinghouse Laboratories at Baltimore, Md., two experimental installations were put into operation during the week of September 17, 1950, for clinical evaluation. Each had a brightness amplification of slightly over 100 times. The first was installed in the X-ray department of Dr. Russell H. Morgan at The Johns Hopkins Hospital, Baltimore. The second is in the department of Dr. Edward Chamberlain at the Tem University Hospital, Philadelphia.

The cover picture shows the device in one of its exp mental forms. Note that the radiologist has had to assu a new position at right angles. The device has been k relatively light and compact. Figure 6 shows a closer v of the apparatus in use. Two polyethylene cables br high voltage to the shockproof gas-insulated housing.

At Chicago in early December 1950 an experimen model was demonstrated to many eminent radiolog Test phantoms simulating a human abdomen were vie alternately with a conventional fluoroscopic screen through the Fluoricon. Detail was readily dem strated with the Fluoricon which was invisible with conventional unit.

Pilot production of the Fluoricon has been started the Westinghouse Bloomfield Works, and design production of the complementary equipment is proceed at Baltimore.

THE FUTURE

THE EFFECT the image amplifier will have on the pr tice of radiology can only be conjectured. Howeve few possibilities are as follows:

1. Long periods of dark adaptation will be elimina Good vision is acquired within three to five minu instead of the previous 25 to 40 minutes.
2. Fluoroscopic examinations can be speeded since increased brightness will permit the acquisition desired information in less time.
3. The radiation dosage to patient and radiolo can be reduced.
4. Stereoscopic fluoroscopy, providing 3-dimensic images, is an important field which will be opened up. ordinary fluoroscopic brightness levels, experimental ster fluoroscopes have been very disappointing. Howe at cone vision levels we can expect good stereofluorosco
5. X-ray motion pictures will become very pract and find medical use, both for teaching and for diagn and industrial use for many research problems.
6. Use of the Fluoricon as a preamplifier for televisi type equipment opens up a whole new field of possibili The image can be placed wherever wanted—includin another room or another city. It can be varied in and contrast, duplicated and even reversed from posi to negative.

Whatever the fluoroscopes of the more distant future be like, it appears certain that the new electron technic will soon place in the hands of the radiologists and indus radiographer vastly improved tools for fluoroscopy.

REFERENCES

1. Fluoroscopes and Fluoroscopy, **W. E. Chamberlain.** *Radiology* (Easton, volume 38, 1942, page 383.
2. Fluoroscopic Image Brightening by Electronic Means, **J. W. Coltman.** *Ra* (Easton, Pa.), volume 59, 1948, page 359.
3. Relation between Visual Acuity and Illumination, **Selig Hecht.** *Journal of Physiology* (Baltimore, Md.), volume 11, 1928, page 255.
4. United States Patent 2,523,132, **Mason, Coltman.** 1950.
5. United States Patent 2,449,493, **Longini.** 1948.
6. United States Patent 2,456,968, **Longini.** 1948.

Stresses in Impregnated Paper Insulation

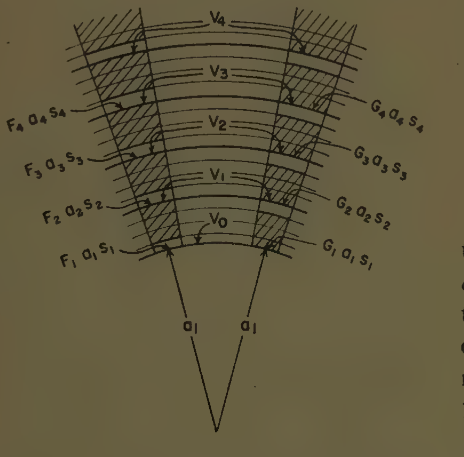
J. B. WHITEHEAD
FELLOW AIEE

WING to the complex dielectric structure of the insulation of a cable, few, if any, attempts have been de to evaluate the stresses in the oil channels in terms of dimensions of the complete cable and the basic di- ctric properties of the insulating materials. A simple lytical solution of the problem is available, however, wo assumptions are made:

. The assembly of paper tapes repeats itself uniformly m layer to layer with exact overlay.

. At the centers of the column of superposed oil nnels there is a region in which the electrostatic stress continuously radial from conductor to sheath.

n Figure 1 are shown exaggerated views of the cross tions of two wedge-shaped tubes of electrostatic in- ction, one starting in an oil channel at the conductor face, and the other in a paper tape at the conductor face. Each tube may be considered as made up of a mber of similar capacitors superposed in series, each acitor having the same number of layers of oil and per—in Figure 1, one layer of oil and three layers of per.



ure 1. Ideal tubes electrostatic induc- n through insula- n of single-conduc- tor cable

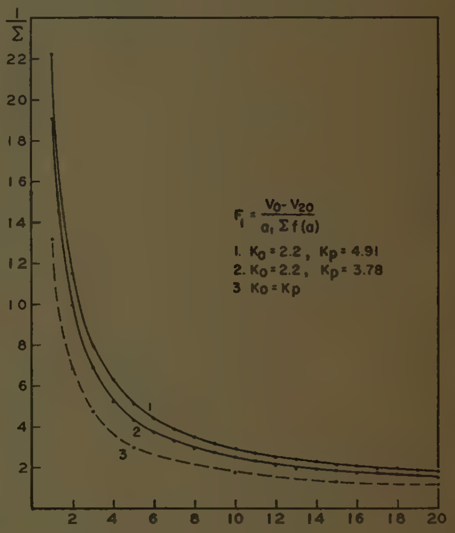
Using the well-known property of a tube of electrostatic duction, *KFS* is constant at all points in the tube, where is the dielectric constant, *S* is the area of cross section of e tube, and *F* the electric intensity normal to *S*, we may termine for a given case the value of the electric intensity stress at any point in our tube of induction, if we know at one point. The values of F_1, the stress in an oil channel the conductor surface, and of G_1, the stress in a paper pe at the conductor surface, may be computed when the applied voltage is given, in terms of a summation of certain functions of the properties of the elementary capacitors making up the tubes of induction.

Thus, we have for a circular, single-conductor cable the following:

$$F_1=\frac{\dfrac{V_0-V_r}{r}}{a_1\sum\limits_{x=1} f(a_x)}\,;\quad G_1=\frac{\dfrac{V_0-V_r}{r}}{a_1\sum\limits_{x=1} \varphi(a_x)}$$

in which V_0-V_s is the voltage from conductor to sheath, a_1 is the radius of the conductor, r is the number of characteristic capacitors in the tube of induction, and $f(a_x)$ and $\varphi(a_x)$ are functions of the radii a_x of the constituent capacitors. These functions involve also the dielectric constants of oil and paper, the thickness of the paper, and n, the number of layers in a characteristic capacitor; in Figure 1 n is 4.

Figure 2. Variation of maximum oil stress with number of layers of paper



These equations may be used for computing the value of the stress at any point in the wall of insulation. In particular, they permit computation of the tangential voltages along the various interfaces. These voltages are due to the out-of-step variations of the voltage gradients along the two tubes of electrostatic induction, as shown in Figure 1. In addition, they show how the maximum oil stress is affected by the use of papers of different densities in the "graded" cable. An instance of the latter is shown in Figure 2 for a single-conductor cable with two papers of different densities in different positions and amounts as insulation. Substituting a higher for a lower density paper in any proportion or position will always increase the maximum oil stress and thus tends to a lower breakdown strength.

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est of paper 51-10, "Radial and Tangential Stresses in Impregnated Paper In- ation," recommended by the AIEE Committee on Insulated Conductors and ap- ved by the AIEE Technical Program Committee for presentation at the AIEE nter General Meeting, New York, N. Y., January 22–26, 1951. Scheduled for lication in AIEE *Transactions*, volume 70, 1951.

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Electric Fences

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THE ELECTRIC FENCE consists of one or more bare wires, such as ordinary barbed wire, insulated from ground, which are energized from a device called a controller. An animal or human touching the wire completes the circuit to ground, thereby receiving a painful but harmless shock. The wire is strung on insulators supported by lightweight poles at a vertical distance about three-quarters of the height of the animal.

Since the primary objective of the electric fence is to control animals by subjecting them to a powerful shock when they contact the fence wire, human beings will be similarly affected, and attention must be given to controlling the shock intensity so that it will be harmless to both man and beast. These two essential requirements of effectiveness and safety present difficult technical problems.

The idea of utilizing electric shock as a means of controlling animals appeals to the imagination. Application appears so simple that many laymen have constructed homemade devices, but too much concern has been given to effectiveness and too little concern has been given to electric shock hazards. Many schemes have been used by the novice, the most prevalent being the use of the ungrounded side of the 120-volt lighting circuit protected only by fuses or by electric lights. Such means may give fair results during ordinary conditions, poor results during conditions of high grounding resistance, and numerous fatalities to both humans and animals during good grounding conditions. These unfortunate instances have done much to discourage both scientific development and application. The homemade gadget has given the electric fence its bad reputation as an executioner of humans and animals. Estimates place the yearly toll between 10 to 15 humans, while animal fatalities are said to be in the hundreds. In contrast to the continuing number of fatalities caused by unauthorized devices, the approved (by the Underwriters' Laboratories, Inc., or Industrial Commission of Wis.) electric fence controller continues to maintain an almost zero fatality record.

Like all mechanical devices, the electric fence is not without its shortcomings. Stock must be trained to respect it. Small animals are difficult to fence electrically. Remote fences are hard to keep in operating condition. Although not recommended for a property line fence or to restrain wild or ferocious animals, the electric fence is a valuable supplement to the conventional fence. It is cheaper and easier to erect. It provides a convenient moveable barrier for controlling grazing. The ease with which the electric fence can be moved permits the subdivision of pasture land on which animals can graze progressively, thereby giving maximum efficiency in the use of land for grazing.

The number of fatalities due to contact with electric fences involving both humans and animals in the late 1930's reached such proportions as to constitute a proble of public safety. As a result, committees composed representatives from agriculture, the electrical professio and local, state, and federal agencies were organized evaluate technical requirements and formulate safe regulations. The results of this effort produced thr safety codes: General Orders on Electric Fences, Industri Commission of Wisconsin, 1938; Standard for Electr Fence Controllers, Underwriters' Laboratories, 193 and Safety Rules for Electric Fences, Part 6, Fifth Editio National Electrical Safety Code, 1940.

Only limited information is available regarding electr fencing in foreign countries; however, recent inqui indicates substantial interest in the subject. The mo recent action was that proposed at Copenhagen, Denmar at which the International Commission for the Regulati and Control of Electrical Equipment (CEE) adopt tentative specifications for electric fence controllers. Th new European tentative standard places the most rig output limitations so far adopted. The effect of reduc shock intensity is of concern, since it is highly probab that the reduced limits will be incorporated in futu revisions of the standards in various countries. As norm precipitation in Europe is somewhat more evenly d tributed throughout the year than in many sections of th country, the resulting improved grounding conditions ma permit effective control with lower shock intensity tha that believed essential for satisfactory operation in th country. Should the lower limits as proposed by the CE be adopted in this country, the value of electric fencing the American farmer might be seriously jeopardized.

The following conclusions can be drawn from this stud The approved electric fence is a safe, effective, and ec nomical aid to modern farming. Homemade electric fen controllers are responsible for the continuing electrocuti of both human beings and animals. The use of su controllers should be prohibited by law. The interests public safety demand that specific enforceable legislati covering electric fence controllers be enacted in each of t various states of this country. Need exists for uniformi in the various electric fence safety codes. With the exce tion of the continuous type of electric fence, it is doubt if the differences in the present codes can be justified the basis of safety. Although compromise in outp limitations is necessary, it is essential that the maximu allowable output not be reduced materially, as any su stantial reduction in effectiveness might jeopardize the val of electric fencing.

Digest of paper **50-2**, "Electric Fences—Their Hazards, Types, Regulations, and Application," recommended by the AIEE Committee on Safety and approved by AIEE Technical Program Committee for presentation at the AIEE Winter Gen Meeting, New York, N. Y., January 30–February 3, 1950. Published in AIEE *Tr actions*, volume 69, Part I, 1950, pages 8–15

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An Immoderate View of Undergraduate Engineering Education

WALTER LaPIERRE
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IT IS POSSIBLE to view the break of the dawn of the atomic age with equanimity, if one is dead; but under no other circumstances. The same may be said of ngineering education.

Recently several new elements have been made. At ast one of these can be caused to explode, confirming the eracity of the 1905 Einstein equation. There is one ement which has no atomic number, although it is said apply to the periodic table, but which is charged and hich possesses explosive qualities. It has been discovered verywhere by all manner of en in all the ages of history. refer to the element of uth. Upon consideration f engineering education, one an discover several elements f truth in the criticisms ssed at it, in the praises hich are its due, and in e students, the faculties, nd the industries whose coxistence make it a going concern. The subject of engieering education is distressingly complicated and deghtfully controversial.

What is wrong with the curricula in engineering schools? Is the lecture method used satisfactory? What are the problems facing the engineering graduate? Mr. LaPierre, of the Columbia University Department of Electrical Engineering, offers his suggestions for improving engineering education.

The Engineering Building at Columbia for 52 years has een energetically operated by a succession of able people nterested in promoting engineering education. The chool of Engineering is one of the professional schools of e University and the training of minds there is known as rofessional education. From this the inference is occaonally implied that the other kind of education is amateur. he proper adjective is liberal, and the distinction between rofessional and liberal education has been made that rofessional education equips one to make a living while e other kind prepares one to live. This oversimplificaon sheds much light on the matter—monochromatic light hich reveals the form of things but alters their colors.

There is profit in reflecting upon the historically revealed urpose of universities which has been said to be threefold: he dissemination, perpetuation, and advancement of nowledge. The mission, constitution, and liability of a chool or college in a university are well focussed in Stephen eacock's relevant discourse on the way he would found a ollege. His idea was to first establish a smoking room here the students could relax and talk in an atmosphere eeped in tradition, then if any money were left he would nstall some books, and finally, if any remnants of the funds still survived, he would hire a professor. It is clear that Leacock had in mind a liberal arts college but the sound wisdom of his opinions about the relative importance of discussing, reading, and listening has a lesson for engineering education. This will be extracted and applied in due course in the following. My own opinion on the desirable situation in engineering education is inferred in my plan for a memorial gift. If I make a fortune and can bequeath a statue to Columbia, my will shall stipulate that it be erected in front of the Engineering Building in symmetry with the foundryman in front of the Mines Building. My specifications will call for a fair and lanky youth in a swivel chair with his hands clasped behind his head, with ankles crossed, and with one heel resting on the edge of a kneehole desk. This attitude of thoughtful repose is hydraulically and physiologically sound and is properly expressive although most of us are decorous and find it unnecessary to assume it until our arteries start to harden. Perhaps I will bequeath my statue to the Electrical Machinery Laboratory where it might also serve some practical purpose.

THE PROBLEMS OF PROFESSIONAL EDUCATION

IN 1927, when Dean Russell retired from his long and eminent service at Teachers' College (Columbia University), he wrote in his last Dean's Report a full, clear, and expressive discussion about professional education as he saw it. The main problems, then, now, and previously, were the overcrowding of the curriculum, the fatigue of the students, and the recruitment of the staff.

Engineering education contains problems which differ from those of the professions of law or medicine. The law is interpreted from precedents established by decisions previously handed down by the courts. Some of these are well known and clearly defined and others are not, so the study of the law calls for immense reading, for a clear understanding of the motives of men, and for the ingenious application of logic. The law has a long history. Medicine has as its territory the human body. The doctors are the descendents of the ancient healers, medicine men and priests who combined much knowledge of their trade with abundant superstition. Medical research for a long time has been engaged in distinguishing these ingredients one from the other. Medical men are occupied with a small empire, about four cubic feet of space on the average,

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but its contents are complicated. However, the professional medical man knows that this is the only domain with which he must deal and can concentrate on it. Both of these great professions have one thing in common in large measure; they are mainly concerned with services to individuals. Engineering is otherwise.

The engineer almost always deals with matters which are the charge of groups of people accumulated either in industrial, in governmental, or in commercial organizations. His duties and the medium in which he operates are subject to the widest variation. For this reason it is difficult to obtain agreement on a definition of the term "engineering" and even more difficult to be sure that engineering education is most efficiently preparing its neophytes for their tasks or careers. The work of the engineer differs further from that of the lawyer and the doctor in the important matter of organization. In his work, the engineer is nearly always one of a collection of engineers who function as an operating unit.

An engineer might be described as the intellectual amalgamation of a combined physicist and chemist who is professionally conscious of the value of a dollar, a mathematician who is willing to arrive at numerical results, a draftsman who prefers to sketch in freehand style, a team worker who has a mind of his own but who can be convinced that there is value in the views of his confederates, and a reporter who can write in clear, brief style. In addition, he will be more useful in his occupation if he is an unhesitating public speaker. Few practising engineers are called upon to make use of the whole of these attainments in full measure, but all must daily call upon several of them in varying degree.

THE TWO CONCEPTS OF THE ELECTRICAL ENGINEER

THE DIFFICULTY in arriving at a unanimous conception of the function of the engineer can be illustrated in many ways. Taking electrical engineering as an example, attention might be drawn to the two views of it which are prevalent in the United States. One of these, which could accurately be called the scholastic opinion, is held by many teachers throughout the land. It maintains that an engineer is one who applies the findings of physics and chemistry, solidified in various electrical, hydraulic, or mechanical components, in a way which may be represented by equations of considerable mathematical complexity, to apparatus or processes, so as to obtain a predetermined operating characteristic from the whole. He does this and continues to do so until he ceases to practice. All of his associates are technicians, clerks, fabricators, designers, draftsmen, or managers but, in any case, not engineers. According to this view an engineer is only one who makes continued and uniformly complex use of mathematical equations. He should preferably be a free agent and not engaged by one company at a time to the exclusion of all others. The other standpoint, which might be called the industrial opinion, holds that the engineer is one who, by virtue of his knowledge of the discoveries of physics and chemistry, the developments of mathematics, and the realities of economics, is enabled, after some years of experience, to see problems of product application, construction, production, or management with a bro
and mature view so that he is capable of making we
considered and reliable estimates of the consequences
action in one way or another. From this standpoint, peo
working in the highly erudite and attenuated technic
fields are seen as technicians. These opposing viewpoin
while necessarily somewhat oversimplified in this
scription, are authentic.

The scholastic view is the result of the experience of
holders and has many worthy consequences. It leads
the search for exact theory and thus to highly analyti
courses of study. It brings to the forefront the discipli
of mathematics with its clear definition and logic.
prevalence is due partly to the fact that most engineeri
teachers are recruited directly from the graduating class
before they have had a chance to work in industry, a
partly to the fact that the academic environment is qu
different from the industrial one. This presently univer
method of reinvigorating engineering departments yiel
insights which are blandly ignorant of the facts of life
industry and which thus encourage a distortion of relati
values in the material which is chosen for furnishing
sparsely occupied minds of the students. The kind
maturity which a teacher must have, if he is to prope
orient his students and educate them with a degree
efficiency, remains undeveloped. The resulting
occupation with technical matters is unreal. One sen
the results of intellectual inbreeding. The students
led by the doctrine that technical competence is an end
itself, worthy of their best efforts for its own sake,
technical erudition in engineering can stand alone
need have no economic justification. So it can in
university, and this is good. But young men trained
way are fitted for work in the university and not for w
in industry where they must unlearn many attitudes.

The reconciliation of these two viewpoints in electri
engineering is a matter of professional concern at
present time. Each convention of the American Institu
of Electrical Engineers has recently contained at le
one session devoted to the adjustment of this misalignme
The realities of engineering employment are rejected
the scholastic viewpoint; the fine distinction of the p
fession of engineering from the various skills, which
its close associates in industry, is not clear to its adhere
and they would like to see the situation of the engin
changed to meet their confined and dogmatic specificatio

PROBLEM OF ADJUSTMENT FOR THE YOUNG ENGINE

THE PROBLEMS of living which are faced by you
engineers must be recognized and teachers who h
not held minor industrial jobs for four or five years f
this difficult. A young graduate trained, by inferen
to think that technical erudition is in the fore is, in his f
years in industry, crushed, disillusioned, balked, and
satisfied. The long period of indoctrination, of train
in organizational arrangements, and of assimilation
specific detail is a desperately disappointing time for
young man who can clearly remember standing, loa
with anticipation, on the front steps of an enginee
school, with his head full of half-forgotten equati

ring a black kimono and holding a square hat in one
d and a tube of high-quality paper in the other. All
would have needed to avoid a disruptive shock would
e been proper realization of the place of theory and of
place of mathematics in the practice of engineering.

t is true that youth is impatient and, I expect, always
l be. Higher education does not and should not attempt
nature the rising generation beyond its years. Educa-
al institutions, however, always serve the society in
ich they exist. Engineering education is no exception,
, if it is to occupy a position of honor, it must serve with
ture insight and accurate knowledge of the needs of the
iety and with a sure sense of the psychological and in-
ectual needs of the students.

LIBERAL ENGINEERING EDUCATION

HERE IS A use for the word 'liberal' in engineering
education. A liberal engineering education would be
ple, abundant, generous, classical, adequate, bountiful,
monious, broad, and thoughtful. It would not be
urried, harried, urgent, discordant, burdensome race
inst time. It would have fewer deadlines and more
king time. An overcrowded program of studies is no
et to the acquirement of an education, regardless of its
stling activity, its apparent thoroughness, and its bright
ay of important courses. Hurried learning is excellent
an occasional concentration of effort, but it is wasteful
l deadly if continued. Engineering education has been
with such pedagogic hyperthyroidism since it was
en out of the hands of the foremen and mastercraftsmen
the 19th century. One can study the dean's reports
any engineering school in the country and discover
t there never was a time when, nor a place where, the
gineering curriculum was not overcrowded. The length-
ng of the program of study from four to five or six years
been and is being tried as a measure to improve this
ndition. It results in five or six overcrowded years
her than only four. Nothing is gained and much is
t by undirected undergraduate academic activity in
fessional education, but students must be given time
l occasion to think and ruminate. Forcing a student
organize his work and to make full use of his time is an
portant and efficient way of ridding him of slothful
bits; however, one term of this cluttered kind would
ch him. Living through four or more terms of such
dley merely causes him to find means of escaping the
rden. In this he is ingenious. Overloading him with
demic work also acts to his detriment by equipping
n with habits of haste which have no place in engineering
culations.

In regard to lengthening the curriculum, there are in en-
eering education two dangers in too much schooling
l these are different from the risks of overschooling in
liberal arts. In engineering there is the likelihood
t the person who knows too many theories will be hin-
ed in solving the problems which face him by the diffi-
ty he will have in deciding which theory to apply. This
a common embarrassment among young graduate
gineers. Also, the young engineer who is too well versed
theory is grieviously threatened by the possession of so much intellectual freight, with the probability of knowing some things which are not so. There are many examples of engineering accomplishments which were achieved because the parties involved did not know they were theoretically impossible. There is advantage in enlightened ignorance occasionally.

The solution of the instructional and educational problem in engineering lies neither in a longer program of study nor in a single undergraduate engineering degree but rather in co-ordination of teaching, in teaching fewer courses, and in teaching liberally and with a light touch. Students naturally concentrate on the work of a driving teacher to the damage of their educational program. One profitable way of meeting this difficulty is to reinstate the system of daily recitations; this is an effective means for keeping a class up to date in its reading without burdening its members with detail which must be handled thoroughly if it is to be done at all. Such reinstatement also would reduce the amount of time devoted to lecturing—profitably in most cases.

THE LECTURE METHOD MISAPPLIED

THE PRACTICE of lecturing a class of students with material taken from a textbook which they all own and which they all can read is probably the most senseless way of illuminating immature mentalities which has yet been devised. There is one exception and that is the more infirm system of lecturing from a text other than the one the students have been instructed to buy. These rituals are not only inane but are also damaging to the students, who can often thus avoid reading the book. Many students have gone through the larger part of a program of study without opening their books except to locate problem assignments. Such perversion lays a blight on individual initiative and debases teaching. As a consequence of it most engineers are forced in later life to learn to understand what they read—at a time when a mistake can be expensive. In this light one can appreciate the wisdom in Stephen Leacock's humor. The great trouble with this degradation of the lecture system of instruction is its waste; not only time is wasted but with it the opportunity of enlightening young minds. That is the golden opportunity. Why would one teach, if he were not willing and anxious to assist students toward understanding and insight? What is a more important occupation for a man than this? The mass poverty of intellect that would permit this method of instruction to exist from ocean to ocean while well-constructed books tumble from our printing presses in immense profusion simply cannot exist. The reason this pernicious and benighted custom has been held over from the days before textbooks were available is that the teachers feel obliged to read the books aloud because the students are injudiciously overloaded. What other reason could there be?

The perpetration of this barbarism is universal, and is therefore erroneously considered inevitable. The development of photo-offset printing has done much to solidify it. The lithoprinters are busily engaged in petrifying lecture notes which should be fleeting things in most cases and, if embalmed this way, will last too long and be an embarrassment. The advertising of one printing firm which campaigned the schools of engineering recently is an innocent text on how to teach badly and how to enhance an academic reputation cheaply and, one might add, at the expense of the students. Such encouragement displays impoverished conceptions of the virtue of the printed word. There is little doubt that our national capacity to print has far outgrown our native capacity to produce material worth printing.

The reason for the continuance of this out-of-date use of the lecture as a means of edifying youth lies in a misplaced sense of responsibility on the part of engineering educators. The teachers are faced with the necessity of the parsimonious selection of material from the vast accumulations of engineering knowledge, a task, as has been noted, for which they have questionable qualifications. Having made such selection, they are then faced with the problem of presenting it to the students and this is where they see their chief responsibility. They present the material, often with rare skill, and conceive that their duty is accomplished; this is the common idea of the word 'teach.' One has a righteous feeling of accomplishment at this task; there is much hustle in it and much exchanging of sheets of paper. However, the pace is always so rapid, the application of the material so tenuous, and the relationship of it to other courses so obscure that the students are unable to sort it out in their minds and thus come to rely on practically pure memory. Engineering education is an outrageously expensive and inconvenient way of accomplishing memory training. It is true that the lecture method properly applied will cover less ground at first but it would have incomparably improved long-range benefits and it would place the emphasis and responsibility on learning, where it belongs. In engineering education the psychological conditioning of the student for learning has uniformly been ignored. The result is the annual propulsion from our technical schools of tens of thousands of half-trained but largely uneducated and unnecessarily immature graduates. In a democracy this is a serious matter.

DEFECTS OF THE LECTURE METHOD MISAPPLIED

THE EFFECT of this method of tutelage is to transform the teacher from an intellectual leader into a combination of brainy boyscout master and crutch. By their dependence on the instructor the students are cheated of the opportunity of displaying initiative; they are led to rely on the daily spooning out of the course material with perhaps a joke or two to make it more palatable. This is altogether the wrong way to learn. Learning is a private matter; the individual is obliged to do it himself. The realization that one can learn from a book unaided is a maturing discovery, which college students should have made many times. The lecture should supplement the book with touches of history, interrelationships with other courses, interpretations, discussions of accuracies to be expected, ranges of application, or any of the profuse variety of such things that a teacher might be inclined to comment upon. The value of this to the students lies in the quickening of their imagination and interest as a result of the larger prospects thus revealed. The lecture meth properly applied yields enormous encouragement intellectual growth and maturity.

There is one other difficulty with the lecture meth when so prostituted. It leads to dogmatic acceptance the textbook material and to the complete loss of insi as to how any given technical situation happens to be th In electric machinery, for example, the elementary te books usually first review the laws of the electric and magnetic circuit, the electrical properties of materials, a the laws of magnetic induction. This material is follow by a chapter on the construction of machinery and oth on the performance, characteristics, and applications of machines. All obstacles are removed for the understand of the useful abstractions about machinery and this helpful. However, if left uninterpreted, it cheats student in at least two ways: it fails to give him a concept of the dynamics of the growth of this body of knowled and it fails to inform him of its most recent trends a developments. Of these the former omission is the m vicious because this insight contains the ingredients what Arthur Koestler has called the 'eureka proce which Poor Richard's Almanac stated tersely and completely in the short sentence "Necessity is the moth of invention." The textbooks do not illuminate t properly; they are composed with different aims; th instruct without educating.

From the elementary machinery book just outlin one would gather that the machines pictured had b developed in orderly fashion from the physical princip enunciated and by the logical sequence of algebr calculations which are always included. One would notably misled by this harvest. The facts are otherw The physical principles were developed, some of th 50 years, before practical dynamos were built. The ea dynamo builders constructed many machines in all so of shapes and often based their designs on false theoreti premises. Poor as they were, these early machines serv long-unsatisfied desires for light and power in a spectacula successful way and were improved as time passed. T important fact in this is that the engineering theory lagg the practice in time. The important truth contain therein is that original discoveries are made when det mined men with restless brains encounter problems wh they cannot solve with the knowledge available to th and who then proceed to worry out a solution, usua by the novel association of a previously unconsidered pla of experience with the problem at hand. Educationa speaking, the momentous thing about Archimedes' Princi is not the law itself, that is well known and easily compassed, but rather the awareness of the mental proc by which it was discovered and the understanding of intense excitement and exhilaration with which its coverer was debauched. Every researcher understa the joy of original discovery and the students should made to realize this phenomenon.

THE NATURE OF ENGINEERING PRACTICE

HOWEVER, engineering is a bureaucratic profession; usually is conducted from a seated position ross desks. The business of the world is largely routine d boredom is the companion of multitudes, as the people Hollywood know well. The employment of engineers ntains uncounted positions of a routine nature. Yet the nployers of engineers rightly expect them to be capable handling the unusual situation as well as the far more merous conventional ones. There is no benefit and ich harm in failure to recognize this actuality. The gineering student must be taught to expect routine ork and to dispatch it promptly and he must be educated think independently and originally. It is the duty of gineering educators to clarify, elucidate, illuminate, and sseminate the knowledge of this reality so that the idents will understand it.

The most productive industries are those which function a routine basis, as Henry Ford demonstrated years ago. outine cannot be avoided and therefore must be resolutely astered. The way in which such mastery can be ac-mplished may be indicated by changing the emphasis om routine, which is a dull, uninspiring manufacturer of tellectual relics, to regular, which is a word with a going, tal, square-shouldered, forward-looking attitude. The fference between disgruntled middle age and vigorous anhood at the prime of life is built into this slight shift emphasis. If young engineering alumni were aware these matters in advance of employment, one would be clined to view their futures with more prompt assurance.

PRACTICE OF ENGINEERING EDUCATION

NGINEERING education is carried on across the land by squads of able, informed, conscientious, mature teachers, platoons of apprentices, trained by apprentices, and by giments of other faculty members who complete the ectrum between these extremes. Each member of this my is dignified by the sincerity of his intentions. All rry on this important task of instruction according to e light as it is seen personally. Eloquent testimony to e lack of damage resulting from their activity exists in e capacity of the industry of the nation to manufacture profuseness of products of great or small technical in-nuity at prices which permit their sale to multitudes. nis is acclaimed throughout the world except in Soviet ussia, where the government simply does not like us d never will, while it remains as presently constituted. ur engineering achievements are mighty. In view of s certainty, by what paradox can there be important ements of truth in the foregoing discussion? The answer this riddle is found partly in the generations of students emselves; one is led to conclude that it is practically possible to damage an engineer by schooling. The nple remainder of the contradiction is explained by the t that engineering education as presently constituted is ghly beneficial to its neophytes. The desire is to make even more advantageous to them and to detect and alter y trends which promise damage or appear regressive.

While there is danger in change, as long as engineering aching holds to the precept of high technical competence mong its practitioners, it will be on firm ground. But s is not enough; more is needed. Maturity, insight, sense of the fitness of things, a level-headed realization of relative values, the ability to be human in the richest sense of the word, the ability to recognize the method, meaning, and value of training and of education, these must also be discovered in the applicants for teaching positions. Each individual will develop his own teaching method and style according to his personality. If his insights and his philosophy are humanly correct, he will develop an understanding of the effects of the program of study on the growth of the students. The older teachers, who have seen generations of students occupy their benches, have small regard for the recent trend toward the development of technicians, which is the way they view the results of the more modern training. It is clear that students have slight respect for easy courses, but it is equally clear that they ought not be swindled by laborious and time-consuming courses, which are supposedly designed to result in intellectual growth and maturity, but which, instead, leave the intellect tired, surfeited, and flaccid. The students are willing to work but they have little interest in technical juggling and ritualistic roguishness.

Fortunately, technical knowledge cannot be inherited. Every student must grow in awareness and he can do this only by his own efforts. In this the teachers can help him by guidance and by example but, most efficiently, by knowing when to stop trying to fill him up with predigested theory. The key to this matter is respect for the student and proper preservation of his right to individuality. As President Eisenhower of Columbia University has said, the student should be educated for dangerous living; any other kind of education is mere training. Hundreds of engineering teachers know these things and practice them.

METHODS FOR ENCOURAGING IMPROVEMENTS

GENERAL improvements are attainable by the uniform action of the engineering schools or by the example and leadership of the endowed schools, which do not depend wholly on tuition fees for support. Maintenance of accredited status is no barrier to proper change. There are no legal requirements governing engineering education which force it to be static. No university legislation exists which prevents emendation in the matter of engineering education. When the engineering faculties are convinced of the correctness and desirability of amendments in engineering education, these will be made. The eternal problem facing all universities is that of obtaining teachers and it is now seen that this is the basic matter here also. There are presently no places where engineering teachers can be taught. Such education of educators will be furthered when men with sufficient stature, liberal insight, and suitable inclinations arise and are heard.

Engineering is a large and various plantation and the quickest way to become familiar with it is to work at it. My final admonition to student readers of *Electrical Engineering* is this: go to work and use the senses with which God endowed you. But remember to look back now and then over the path which you have travelled and perhaps exchange experiences with those who tried to prepare you. Thus to hasten the time when my proposed statue of the young thinker will come closer to representing actualities in the engineering schools of the nation.

Centralized Control Board for Steam-Electri Generating Plants

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THE CENTRALIZATION of boiler, turbine, generator, and auxiliary electrical control functions has had considerable attention during the past decade in plans and designs of new steam-electric generating plants. The result accomplished is basically a grouping of the several conventional control boards, formerly placed at scattered locations, into a specific area. The plan of such a typical control room is shown in Figure 1, from which it is seen readily that a considerable area of valuable station space is required and that simplicity of operation has not been wholly attained.

In the design of the new Morgan Creek Plant for the Texas Electric Service Company, a new approach to centralized control for all combustion, steam, and electrical power facilities has been taken. Of greatest importance is the opportunity afforded for one man to have a comprehensive knowledge of the entire plant performance, and for all important operating functions to be under the control of one operator. Another major advantage is that the new design resulted in approximately a 50-per cent decrease in the control-room area and a substantially larger reduction in linear footage of the control panels.

Centralization of boiler, turbine, generator, and auxiliary controls has been introduced into generating plants so that one person can know all the conditions in the plant; thus the plant can be operated most efficiently. This method also cuts down the necessary amount of control-room area.

This new and compact centralized control board is of the duplex-type benchboard construction and is shown in Figures 2 and 3 for front and rear areas respectively. Each of the two boiler-turbine-generator sections is 7 feet long. The entire control board, which includes a 4-foot-long transmission-line control and relay section, is 18 feet long. The structure is 7 feet 6 inches high and 5 feet deep between the vertical panels. The bench section protrudes 1 foot 9 inches beyond the face of the vertical panels. This station consists of two unit-type boiler turbine-generators. Each boiler is suitable for gas or oil firing and is rated 220,000 pounds per hour, 925 pounds per square inch gauge, and 905 degrees Fahrenheit. The turbine-generator is rated 20,000 kw, 850 pounds per square inch gauge, 900 degrees Fahrenheit, 3,600 rpm, 13,200 volts. The generator is hydrogen-cooled and is equipped with a direct-connected exciter. This plant began operation in June 1950.

Designs are completed, plant construction has begun, and manufacture of the centralized control boards is under way for several other new plants having a combined capacity of more than 700,000 kw.

Centralized control boards now are being furnished f new boiler-turbine-generator units rated 75,000 kw, and it anticipated that such boards can readily be applied, wi only minor modifications to the basic design, to units rate up to 125,000 kw.

Figure 4 shows the operating floor plan of a new 2-un 132,000-kw plant employing the new type of centralize control board. This plant is arranged so that it may l enlarged in the future for the installation of a similar add tional centralized control board for the ultimate control four large units from one central area. Although this ma be considered a rather bold step in furthering centralize control to an extent not previously attempted, it is consi ered logical and reasonabl particularly for the sing boiler-turbine type of pla design.

One of the disadvantag of the conventional centr control area is the substa tial amount of valuable spa it requires in the most co gested part of the plan Obviously, to obtain an a preciable reduction in the size of this area, the vario boiler, turbine, generator, and auxiliary control pane must be made smaller. In planning and working alo these lines, the new and compact centralized contr board evolved and has demonstrated its worth in effective reducing space requirements. In its final design, oth economies in plant construction, installation, and operati facilities are being realized.

COMPACT DESIGN

THE COMPACTNESS of the centralized control board w achieved in various ways. First, careful consideratio was given to include only those indications and controls th the central control-room operator will require for easy a efficient adjustment of the various boiler, turbine, a generator auxiliaries during normal and emergency opera ing conditions. Secondly, all front-of-panel instrumen gauges, and control devices were selected to secure t minimum size consistent with required readability a accuracy and for ease and convenience of manipulatio Particularly, for the boiler and turbine sections of the boa instruments are of miniature proportions as compared wi

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Full text of paper 50-223, "Centralized Control Board for Steam-Electric Genera Plants," recommended by the AIEE Committee on Power Generation and appro by the AIEE Technical Program Committee for presentation at the AIEE Fall Gen Meeting, Oklahoma City, Okla., October 23–27, 1950. Published in AIEE *Transact* volume 69, part II, 1950, pages 1438–51.

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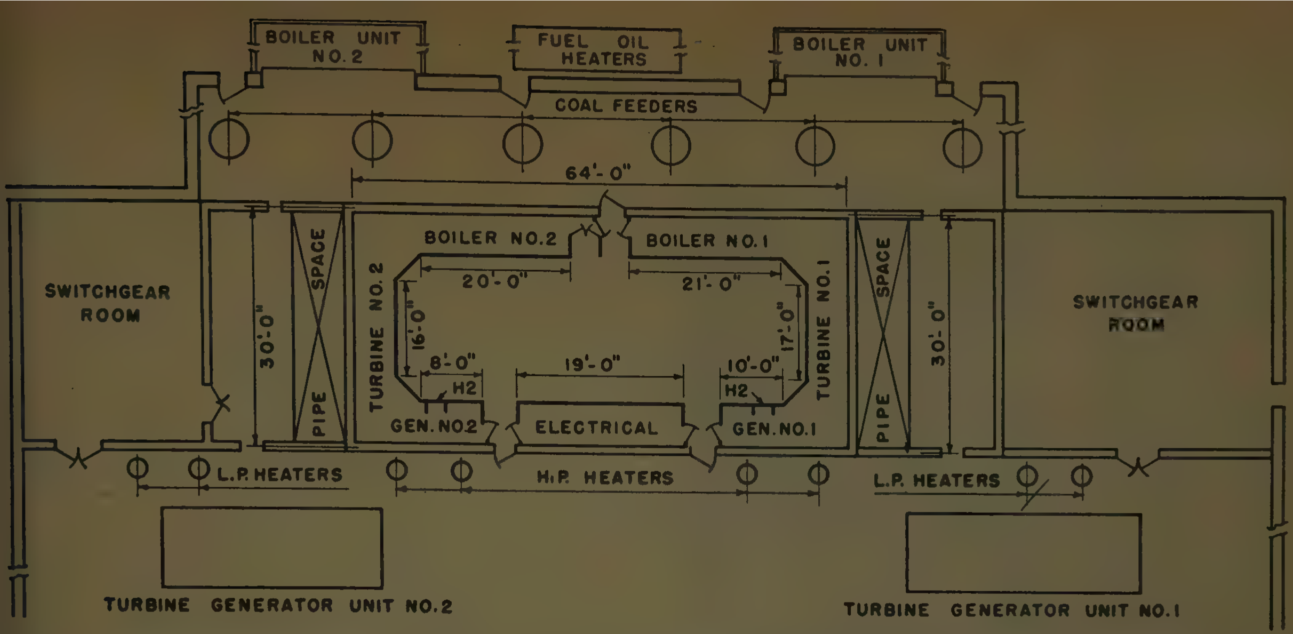
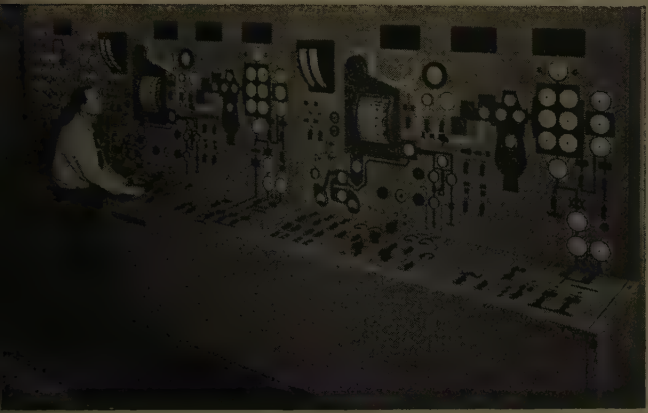
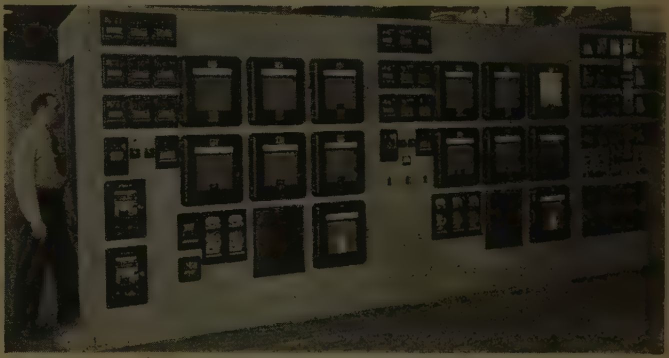


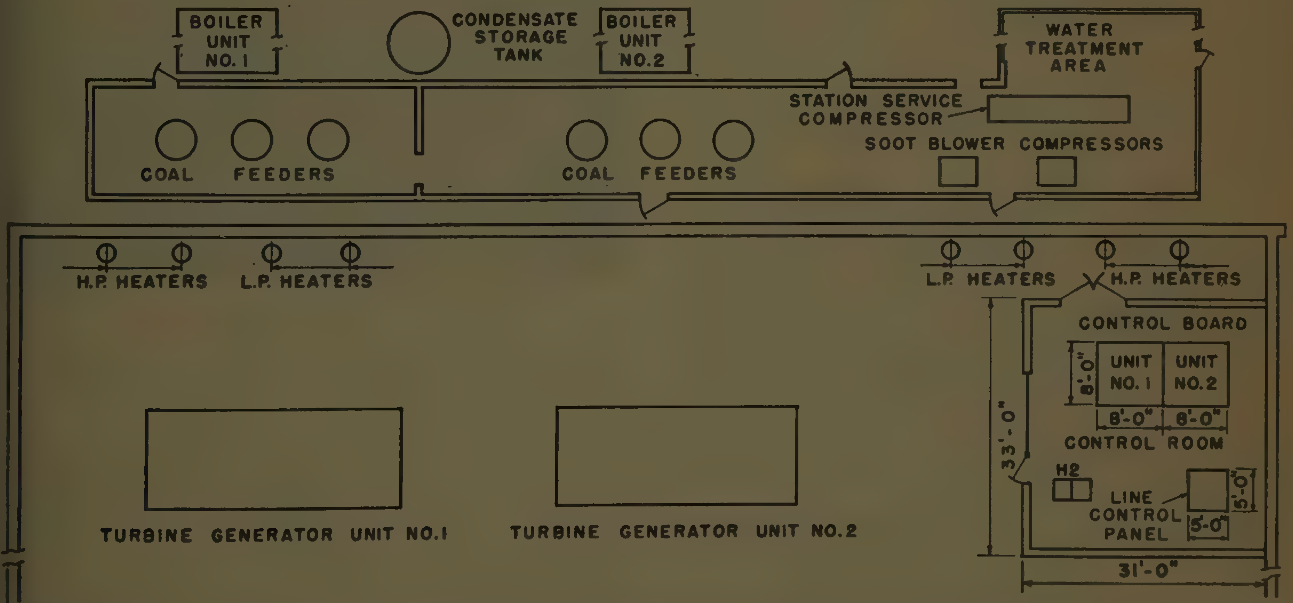
ure 1. Operating floor plan of a recent 88,000-kw steam-electric station showing conventional control room with individual boiler, turbine, and electrical control boards





Photographs courtesy Texas Electric Service Company

ure 2, left, shows front elevation and Figure 3, right, the rear elevation of the new 2-unit centralized control board recently installed at the Morgan Creek steam-electric station of the Texas Electric Service Company



ure 4. Operating floor plan of a new 132,000-kw 2-unit steam-electric station showing reduced control room area requirements by using the new 2-unit centralized control board design with separate transmission-line control unit

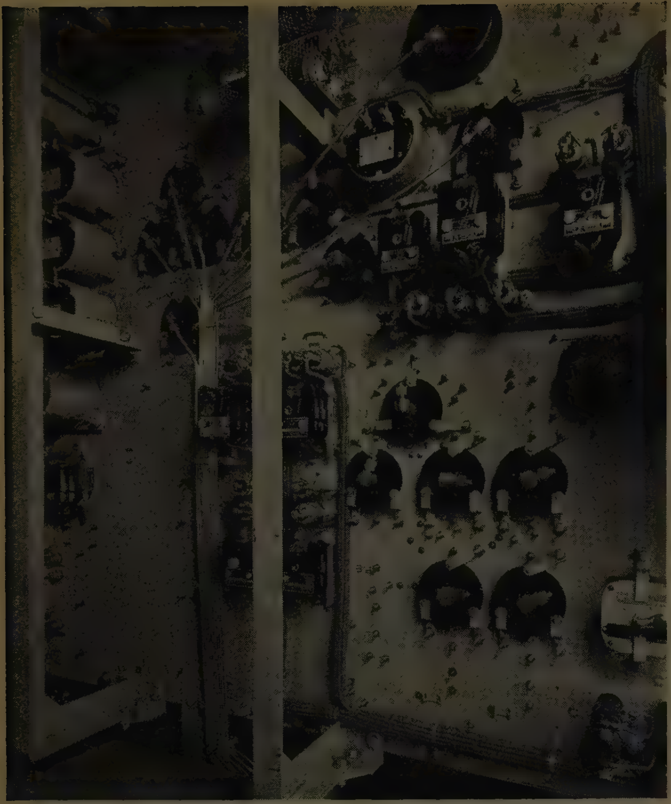


Figure 5. Back view of control panel showing partially installed low-pressure piping to a group of gauges

conventional instruments ordinarily used on boiler-turbine gauge boards. These smaller instruments utilize the principle of retransmission of indications, with low-pressure compressed air as a medium, controlled by transmitters integral with normal full-sized instruments located remotely. This principle of retransmission results in the total elimination of high-pressure piping to the control board, thereby further contributing to compactness of design as well as to installation economies. Finally, the duplex type of construction of the centralized control board facilitates the efficient use of space and provides sufficient area on the rear panels for all recording instruments, watt-hour meters, relays, and automatic station oscillographs, if they should be required.

SAFETY

WITH THE ELIMINATION of all high-pressure control and instrument piping from the central control board, any possible damage to the equipment or injury to operating personnel from the dangers of live steam, water, oil, gas, or similar hazards is removed. No barriers or compartmentation is required for protection of electrical connections against steam, water, or mercury leaks, or spillage. This further contributes to simple and economical control-board construction.

Figure 5 shows the compactness and simplicity of installation of low-pressure piping to a group of gauges.

The control board is of dead-front construction throughout, with no exposed electrical connections on the outside surfaces, which further contributes to safe operation.

DESIGN ADVANTAGES

THE NEW centralized control board is flexible in ap cation to various operating requirements and con tions, as space is initially provided for the maximum nu ber of instruments and controls for which need may reas ably be anticipated. For the various control boards ready built or now under construction, the only ma differences among them are the number of fans per boi number of boiler-feed pumps, and the differences in f usage and in the combustion control systems.

The basic design of the board provides instruments a controls for AIEE-ASME preferred standard and han book turbine-generators. It can be modified readily accommodate central control requirements for the mo complicated installations, such as those employing reh cycles.

Of major importance is the opportunity afforded saving in operating personnel. Except for the starting the plant, essential normal operations can be controll entirely from the control board by one man. In starting cold, the opening and closing of drains, the starting miscellaneous motors, and various other local manu operations are required. These are not necessarily sim taneous, but, in general, can be handled by a man who, other times, attends to routine plant duties.

The compactness and the arrangement of the cont board offer the advantage of making it possible for one m to have a comprehensive grasp of the entire plant perfor ance. Meters and gauges on two adjacent boards easily read and controls are within convenient reach fr a central operating location, so that one man can cont normal operation for a 2-unit plant. The extent to whi

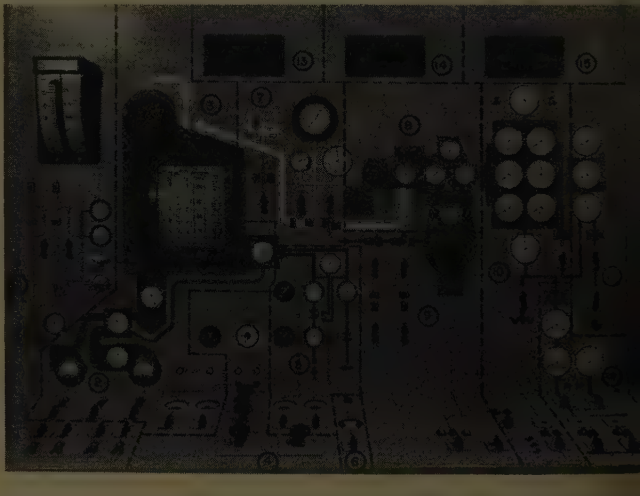


Figure 6. Control and instrument section for one boiler-turbi generator unit. Numbered sections outline basic indication control groupings. (1) Boiler feed pumps and feedwater re lator controls and gauges; (2) boiler draft and air heater cont and gauges; (3) boiler gauges; (4) combustion control; (5) (gas and oil) controls and gauges; (6) steam temperature contr (7) main steam and throttle valve controls and gauges; (8) bine and condenser gauges; (9) condenser circulating water condensate control; (10) a-c generator and main transfor controls and instruments; (11) d-c exciter controls and ins ments; (12) station service transformer controls and instrume (13) boiler annunciator (15 indications); (14) turbine ann ciator (21 indications); and (15) generator and transformer nunciator (17 indications)

can be done for unusual or emergency conditions will nd upon the capabilities of the operator and the com- ities of the plant and the electric system to which it is ected.

nother advantage is the reduction in size of the room ired to house the control equipment. This represents a sizable saving in structure, lighting, ventilation, and onditioning costs. Although additional costs for re- smission facilities are involved, the net savings in capital stment by the use of the combined board are substantial.

FUNCTIONAL

MIMIC DELINEATION of major units of apparatus such as the boiler and accessories, induced and forced draft turbine, condenser, generator, and shaft exciter, is ned on the face of the control board. Their arrange- t is in a logical manner so that the power production ess from fuel to generator output can be followed read- The various instruments and gauges associated with a ific piece of apparatus are confined within its mimic as far as practicable. To present to the operator a picture of the function he is observing or controlling, principal runs of piping and electric circuits are likewise n in mimic form, and are identified by distinctive rs for the various functions.

any of the control devices, indicating lamps, and es are incorporated directly in the mimic system. re indicators for similar functions are located close to other, further identification is facilitated by different red dials. Safe and unsafe operating ranges are visually n on pressure-gauge dials by the use of red and green zones. The green zone represents safe operating ranges, while the red zones, on one or both sides of the green zone, represent abnormal or unsafe operating ranges. To represent valve positions, rectangular signal lamps are located in the mimic piping system, one parallel and one at right angles to the piping, so that both color and position will indicate whether or not a piece of equipment is in use. Green lights at right angles to the piping indicate equipment out of service, while red lights parallel to the piping indicate equipment in use.

Such a complete diagrammatic representation should facilitate acquainting new operators with equipment functions. It also should aid in the interpretation of indications and enable fast and accurate manipulation of controls involving both steam and electrical elements in well-coordinated sequential operations. This is of the greatest importance in an emergency.

To indicate the extent of the various control functions and instrumentation provided at each of the two boiler-turbine-generator sections of an installed centralized control board, Figure 6 is shown divided into numbered zones.

Although the design concept of the centralized control board is new, none of the applied components are new or untried. As a result, the development has met with widespread interest and acceptance, particularly for new generating plant designs. Control boards of the new type are now installed, or on order for factory fabrication, for a total of 13 generating units in ten steam-electric stations of eight operating companies. This has made possible a high degree of standardization usually not achieved with a new development in such a relatively short period of time.

dvances in Ultraviolet Equipment

J. H. LAUB
MEMBER AIEE

Industrial application of ultraviolet radiations has expanded recently to the extent that electrical engineers now frequently must be concerned with various types of ultraviolet lamps and their associated electric control equipment. These applications range from germicidal uses to sterilization of liquids and various photochemical processes.

LTRAVIOLET radiations are generated as a result of quan- processes when an elec- current passes through ed gases or vapors.[1] The tity and quality of the violet radiations thus ed depends on the nature the pressure of the gaseous sphere through which the discharge takes place. Mer- vapor is the most commonly used medium in commer- ultraviolet sources although lately rare gases, particu- xenon, as well as mixtures of metal vapors, for instance, mercury and cadmium, are gaining in importance because of their spectral characteristics or for other reasons. The pressure of the gaseous atmosphere is determined by the temperature of the vessel containing it, and the latter in turn is affected by the wattage per inch of arc length. Since the pressure influences both the spectral distribution and the intensity of the ultraviolet output,[2] it is useful to classify ultraviolet sources into three pressure ranges, namely, low pressure, high pressure, and super-high pressure. The low-pressure range covers pressures from about 10^{-6} to 10^{-1} millimeters of mercury and loadings up to about one watt

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per inch of discharge length. High-pressure lamps operate at pressures from about one-third atmosphere to several atmospheres and at loadings of approximately 20 watts per inch to 150 watts per inch of arc length. The recently developed compact light sources[3] operate at internal pressures of up to 60 atmospheres and with wattage loadings as high as 1,000 to 25,000 watts per inch in the arc. They are referred to as super-high-pressure lamps.

LOW-PRESSURE LAMPS

A DISCHARGE between solid electrodes, which may be activated, in a low-pressure atmosphere of mercury excites the atoms and molecules of the vapor to emit strongly the "resonance" radiation of 2,537 angstroms as well as very short wave ultraviolet at 1,849 angstroms. Both are very efficient bactericidally. If a tubular envelope of pure fused quartz is used to enclose the low-pressure mercury-vapor discharge, approximately 95 per cent of the total radiation output in the visible and ultraviolet is emitted in the 2,537-angstrom and 1,849-angstrom range. If a Vycor glass envelope is used instead, the short radiation at 1,849 angstroms is suppressed while the 2,537-angstrom radiation is transmitted with but little attenuation. Tubular low-pressure mercury-vapor lamps are widely used for germicidal applications in hospitals and physicians' offices, for instance, for the prevention of bacterial contamination and cross infection in contagious wards. An example of a portable germicidal ultraviolet source that can be wheeled into a hospital room after the evacuation of a patient or into an operating room before and during operations is illust
in Figure 1(A). It consists of two vertically mounted 30-
long Vycor lamps which produce about seven watts o
micidal energy each. When portable germicidal ultra
lamps of this type are used in operating rooms the su
staff either wears goggles or eye shields for protection o
lamps are positioned sufficiently far away from the op
ing table to eliminate the possibility of conjunctivitis o
mation of lesions. These effects can be produced onl
prolonged exposure to ultraviolet radiation of an e
level far in excess to that normally produced by such l
located sufficiently far away. Ultraviolet lamps of a si
type are used in a variety of specially designed fixture
upper air sterilization in school rooms, offices, and so f
They are also advantageous in air-conditioning duct i
lations and practically indispensable for the preventi
contamination by microorganisms in pharmaceutical p
in connection with ampule and bottle filling.

More recently the sterilization of biologic fluids by m
of ultraviolet radiation from low-pressure mercury disch
lamps is attaining considerable importance. Human b
plasma, Adreno-Cortico-Tropic-Hormone (ACTH),
cines for rabies, poliomyelitis, and other biologics are b
processed successfully by exposing thin flowing films t
tense short-wave ultraviolet radiation. Film thicknes
less than 0.001 inch are required due to the strong ab
tion of short-wave ultraviolet. They are created eith
centrifugal force on the surface of a rotating drum o
forcing the biologic fluid through flat fused quartz

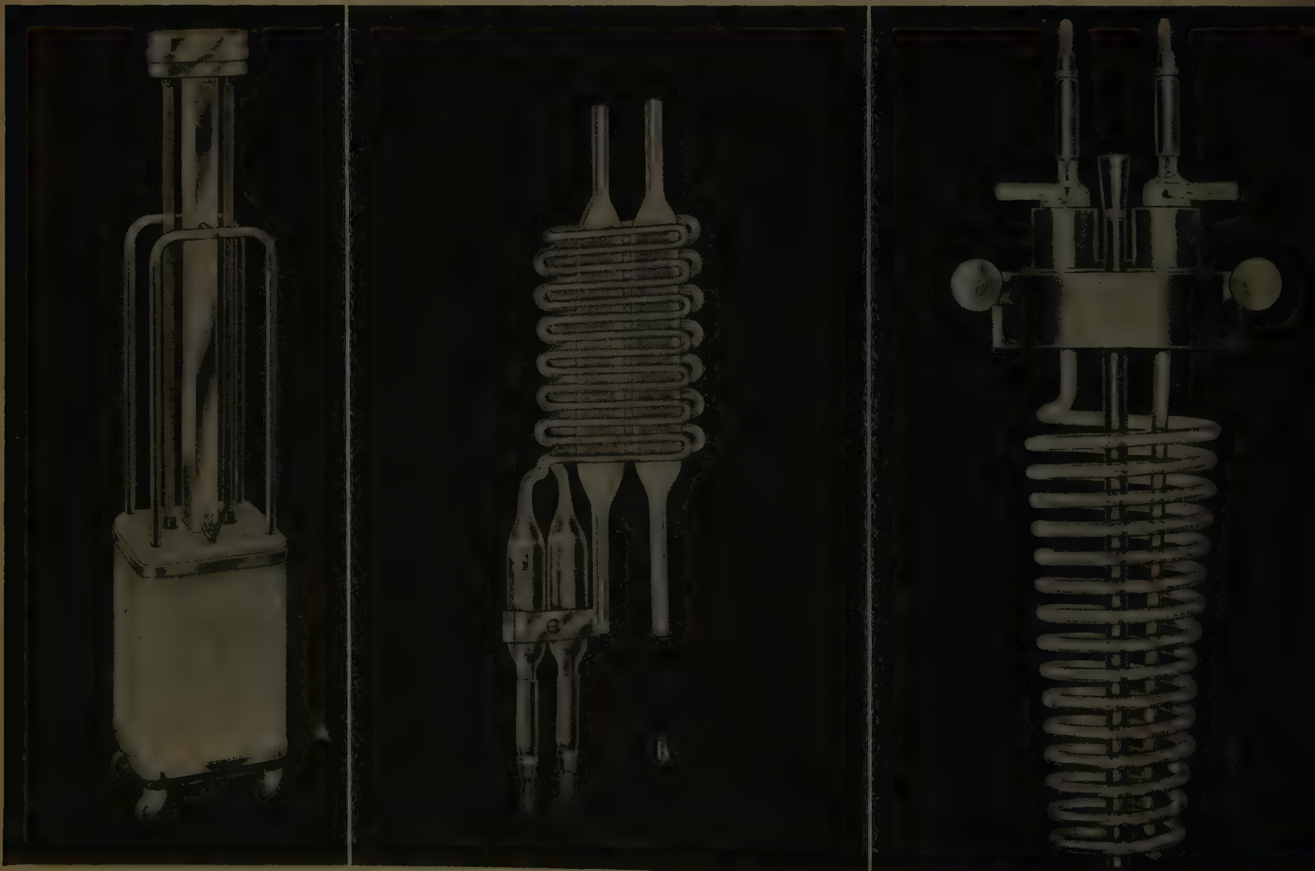

Figure 1. (A) Portable germicidal ultraviolet source, (B) special germicidal lamp and fused quartz cells for the sterilization of biol
(C) spiral-type quartz low-pressure ultraviolet lamp

se walls are spaced about 0.0008 inch apart. An ex- le of the latter is illustrated in Figure [illegible]. The two rtz cells through which the biologic flows are surrounded specially designed low-pressure mercury lamp which is nder-shaped and, operating on 120 milliamperes, pro- es a total output of germicidal radiation of 15 watts. sterilizing capacity of the unit illustrated is six liters of ma per hour. A completely closed system is used which nits the transfer of the biologic from one container to ther within the system without contamination through osure to external conditions. It comprises, besides the rtz cells and the ultaviolet source, a nitrogen tank with a pressure regulator and manometer and a liquid flow er for the measurement and control of the flow rate of biologic. A multiple installation of these units is used he Armour Company in Chicago for the sterilization of TH which is produced from the pituitary glands of hogs. as been applied successfully in the treatment of rheuma- arthritis, severe burns, and other conditions.

nother example of a special spiral-type quartz low- sure ultraviolet lamp that is conically shaped to fit in- of a spinning stainless steel drum on which an even thin of plasma forms by centrifugal action is shown in ire 1*C*. The prevention of Virus Hepatitis, a form of dice with sometimes fatal outcome, and resulting from sfusions with contaminated pooled plasma, has become atter of great concern to the medical profession. The eral Security Agency of the National Institute of Health issued stringent regulations for the treatment of human ma with ultraviolet irradiation. Control tests for lity are specified, using a sample of plasma contami- d with the reference culture of Aerobacter Aerogenes. r ultraviolet exposure an initial total bacterial count of more than ten bacteria per milliliter is acceptable.

order to meet these requirements the ultraviolet ces have to be carefully designed and processed. The tion of the optimum dimensions, operating tempera- s and pressures, and the use of an envelope material a minimum of solarization are among the important rs in assuring maximum bactericidal radiation output minimum deterioration in time. The lamps are sub- d to careful measurements of the ultraviolet output and ologic standardization tests before installation.

HIGH-PRESSURE LAMPS

HE INDUSTRIAL APPLICATIONS of high-pressure vapor amps have greatly expanded in the last decade. ular lamps with envelopes of fused quartz, Vycor, or x glass with wattage inputs up to 7,500 watts and nous lengths up to 66 inches are widely used for photo- ical processes. They are rich sources of photoactinic tion with strong bands at 3,130, 3,340, 3,660, and 5 angstroms and are, therefore, ideally suited for oreproduction equipment such as photoprinting and printing machines, equipment for film copying and ing, copy board and engraving equipment in the hic arts industries, photographic enlargers, and so .[4] An example is a high-pressure mercury-vapor lamp 500 watts input and 54-inch luminous length, which developed for a high-speed photoprinting machine.

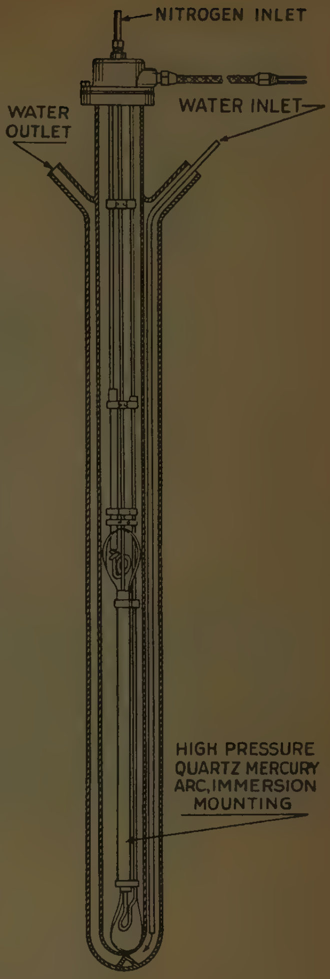

Figure 2. **Immersion-type high-pressure ultraviolet lamp for photochemical processes**

The arc forms between solid activated electrodes which are sealed into an envelope of transparent fused quartz. The latter is surrounded by a jacket of Corex glass which protects the arc tube from the impact of the air for cooling the printing cylinder which rotates around the lamp. It is interesting to note that as of January 1951 approximately 20,000 automatic photoprinting machines were equipped with high-pressure mercury-vapor lamps, representing a total of approximately 75,000 kw of installed capacity.

The chemical industries are using more and more mercury-vapor high-pressure ultraviolet sources for photochemical reactions. Among these the bonding by polymerization with ultraviolet light of steel and Fiberglas laminates to plastic sheets, the synthesis of Vitamin D by ultraviolet irradiation of sterols, and the photochlorination of benzine in the manufacture of insecticides may be mentioned. Figure 2 shows a special assembly of a high-pressure lamp which has been developed for immersion into photochemical reaction vessels. The high-pressure lamp is inserted into a glass well into which nitrogen is bled and which is surrounded by a water jacket for cooling purposes.

Furthermore, high-pressure ultraviolet mercury vapor lamps are used extensively for the sterilization of water and other liquids in breweries, bottling plants, and the food industries. Among the lines of the high-pressure mercury-vapor spectrum that are bactericidally most effective and utilized in sterilizing equipment of this kind are radiations at 2,482, 2,537, 2,650, 2,699, 2,967, and 3,130 angstroms. A completely automatic liquid sterilizing unit which employs a 1,200-watt quartz lamp and has a sterilizing capacity of 1,800 gallons of water per hour is shown in Figure 3. Accessory safety devices automatically shut off the water flow in case of power failure or malfunctioning of the ultraviolet lamp and thus prevent the flow of unsterilized water.

A cadmium mercury high-pressure lamp of 400-watt input has recently been developed as a radiation source for the photosensitive glass process of the Corning Glass Works.[5] The cadmium emission lines at 3,404 and 3,466 angstroms supplement the spectrum of the mercury vapor in the range from 3,000 to 3,500 angstroms to which this new glass is sensitive.

The development of special electric control gear that

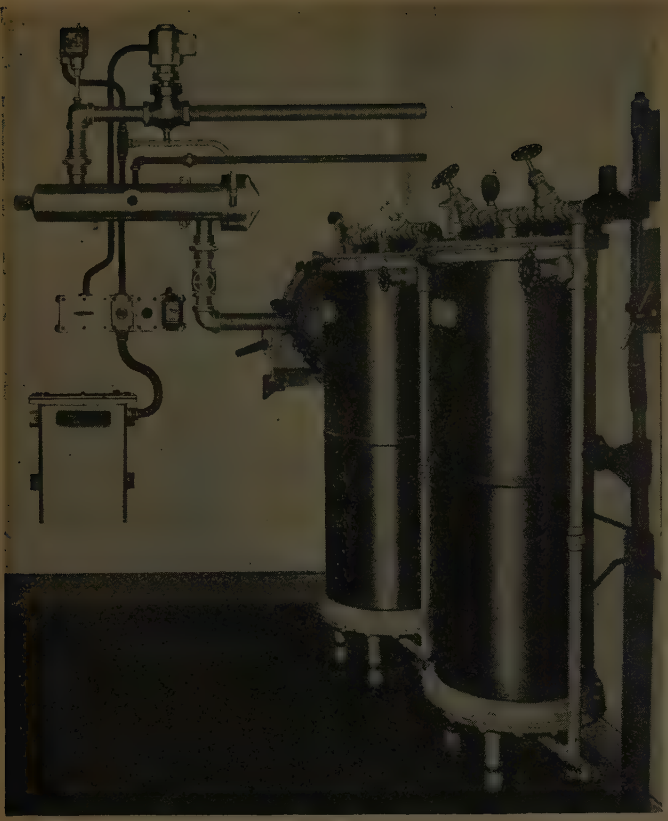

Figure 3. Automatic ultraviolet water sterilizing installation

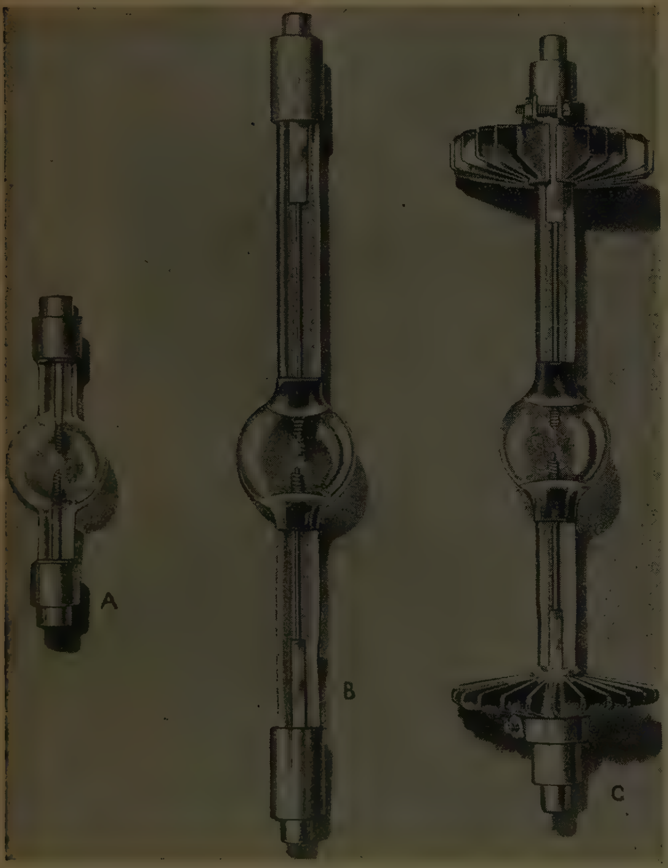

Figure 4. Super-high-pressure compact sources with wattage inputs of (A) 150 watts, (B) 700 watts, and (C) 1,000 watts, respectively

permits high-pressure lamps to operate with practically c stant output on power supply lines with widely vary voltages constitutes an important advance. This is complished by using a transformer with high core saturati in series with a capacitative ballast, a combination which the same time results in a unity or a leading power factor the supply lines. Stabilizing control units are becomi standard equipment for high-pressure ultraviolet lamps.

SUPER-HIGH-PRESSURE LAMPS

SUPER-HIGH-PRESSURE LAMPS are compact and hig efficient sources of visible, infrared, and ultravio radiation. A short arc is formed between solid tungst electrodes which are sealed into a bulb of transparent fus quartz of high grade (see Figure 4). To prevent bursti at the very high operating pressures (20 to 60 atmospher wall thicknesses of 3 to 5 millimeters are required. For nately the tensile strength of fused quartz increases w temperature and reaches a maximum in the vicinity of operating temperatures of these lamps (around 800 degr centigrade). However, great care has to be exercised the manufacture of the heavy-walled quartz bulbs and se to avoid stresses and strains or other imperfections wh might weaken their structure. The distance between electrodes is very short, for instance, 3 to 10 millimet depending on the size and wattage of the lamp. With tremely high wattage loadings in the arc this results in trinsic brilliancies of 200 to 1,000 candles per square mi meter. Compact source lamps are therefore specia suited for use with reflectors and optical lens systems.

Figure 4 shows three types of compact sources, w wattage inputs of 150, 700, and 1,000 watts respective Larger lamps with wattages up to 10,000 watts have b built experimentally.

Compact sources may be operated either with a resist or reactive ballast in series with the lamp. The startin the arc requires voltages of several thousand volts. Th are usually produced by high-frequency pulses from capacitor-discharge and spark-gap circuit.

Interesting possibilities for ultraviolet applications offered by compact lamps with a high-pressure atmosph of xenon gas. They create a continuous spectrum in ultraviolet as is required, for instance, for absorpt measurements by means of spectrometers and similar struments in which the less efficient low-pressure hydro lamps have been used heretofore.[7] Super-high-press lamps also promise to find useful applications in the th peutic and industrial ultraviolet fields.

REFERENCES

1. The Search for High Efficiency Light Sources, **Saul Dushman.** *Journal*, O Society of America (New York, N. Y.), volume 27, 1937, page 1.

2. Electronic Tubes for Ultraviolet Radiation, **J. H. Laub.** *Electronics* (New N. Y.), May 1943.

3. Discharge Lamps for Photography and Projection (book), **H. K. Bourne.** man and Hall, Ltd., London, England, 1948.

4. Powerful Ultraviolet Light Sources, **J. H. Laub.** *Electrical Engineering*, volu August 1941, pages 384–8.

5. New Glass Developments in the Field of Illumination, **W. W. Shaver.** *Illumi Engineering* (New York, N. Y.), October 1950, page 631.

6. United States Patent 2,482,894.

7. Ultraviolet Radiation of the High Pressure Xenon Arc, **W. A. Baum, L. Du man.** *Journal*, Optical Society of America (New York, N. Y.), volume 40, numb 1950, page 782.

A Modern Cab Signaling and Train Control System for Railroads

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Increased safety of train operation is effected by the continuously controlled cab signal which may be augmented by means for automatically applying the brakes in case cab signal changes calling for a reduction in speed are ignored or predetermined speed limits are exceeded.

THE OUTSTANDING feature of modern systems of automatic train control is the signal in the cab. It provides in the cab, in full view of the engineman, miniature counterpart of the familiar wayside block nal.

The control of the cab signal indications is transmitted m the wayside to the locomotive through inductive ıpling between alternating rrent flowing in the rails d a pair of iron-cored re- ving coils on the locomo- e. Changes in the charac- of the rail current, pro- ced by changes in traffic nditions ahead, cause cor- ponding changes in the cab nal aspect. Thus, the cab nal gives a continuous indication of conditions ahead, and y change in these conditions affecting the safety of the train reflected instantly in the cab signal indication regardless the position of the train with respect to the wayside nals. This not only promotes increased safety of train eration but reduces delays by permitting the engineman increase speed when the cab signal changes to a more orable indication without waiting until the next wayside nal is in view.

The controls on the locomotive which govern the cab nal indications are used in conjunction with other paratus to enforce obedience to changes in these indica- ns that require a reduction in speed. On some rail- ıds the control of the train speed is left entirely in the nds of the engineman, but any change in the cab signal a more restrictive indication is accompanied by the ntinuous sounding of an audible warning device in the b. The engineman may silence this audible indication, d thereby acknowledge his awareness of the changed nditions, by actuating a lever within his convenient reach. ould the engineer, for any reason, fail to acknowledge, continued sounding of the warning device directs the man's attention to the need for action.

The controls may be arranged to apply the train brakes omatically if the engineman fails to heed the audible rning and to acknowledge within a specified number of onds after the cab signal changes to a more restrictive ication. Once the automatic brake application has gun, it cannot be released until the train has been brought a full stop or the cab signal has changed to a less re- ctive aspect.

The cab signal also may form the foundation of a speed trol system in which a governor fixes certain speed limits in accordance with the information given by the cab signal. A number of speed limits may be imposed up to, but not exceeding, the number of cab signal indications provided.

An automatic brake application caused by running above authorized speed may be suppressed by manually applying the brakes until the pressure in the brake cylinders reaches a predetermined value or the speed has been brought below the limit.

There is also a selection in the rate and gradation of the automatic brake application. The brakes may be applied in emergency or at the manual service rate. If the latter, the brake pipe reduction may be unlimited or it may be limited to a value that will insure stoppage of the train within the allotted distance. The limited reduction can be made in two steps, the first of which serves to bunch the slack in the train before the second, or heavier, reduction begins.

It can be seen that there are available many different combinations of train control apparatus arranged to meet the varied operating needs and requirements of the different railroads. It is the purpose of this article to describe one such combination: that comprising a 4-indication cab signal system with 4-speed control. This combination has been selected as the example because it is so extensive in its scope that it includes all of the main features that may enter into a train control system.

HISTORY AND DEVELOPMENT

THE ERA of continuous inductive cab signaling and train control began on July 11, 1923, when an installation of 3-indication 3-speed automatic train control was placed in service between Lewistown Junction, Pa., and Sunbury, Pa., on the Pennsylvania Railroad. Its use has been extended until today more than 5,600 motive power units and 9,700 miles of track are equipped with cab signaling or continuous train control.[1]

The early train control systems were based upon the use of steady (uncoded) alternating current in the rails. For a 2-indication system, current of opposite instantaneous polarity flowed in the two rails from the low-voltage winding of a transformer connected across the rails at the

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Essentially full text of paper 51-34, "A Modern Cab Signaling and Train Control System for Railroads," recommended by the AIEE Committee on Land Transportation and approved by the AIEE Technical Program Committee for presentation at the AIEE Winter General Meeting, New York, N. Y., January 22-26, 1951. Scheduled for publication in AIEE *Transactions*, volume 70, 1951.

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leaving end of the track circuit. Presence of this current in the rails under the receiver produced a "clear" signal in the cab. Absence of current, as when shunted away by the wheels and axles of a train ahead, produced a "restricting" cab signal. To obtain three cab signal indications, it was necessary to superimpose a second rail current upon the first and to provide on the locomotive a second receiver which would be responsive to it. This second current, called the loop current as distinguished from the first, called the track current, was caused to flow through a bridge circuit in which the rails and a mid-tapped resistor connected across the rails at each end of the track circuit formed the balanced arms. The loop and track currents were in quadrature phase relationship.

The steady current systems possessed two important disadvantages which limited their usefulness. These were: 1. No more than three cab signal indications or controls could be obtained without using alternating current of more than one frequency. 2. Difficulty in confining the loop current of the 3-indication system to its designated track circuit, particularly in electric propulsion territory where cross-bonding and supplementary negative conductors provided diverting paths.

In these early systems, the train control relay was an a-c vane type energized from a 2-stage 2-phase amplifier. The amplifier contained four triode vacuum tubes which required a 350-volt d-c plate supply. It is of historical interest that, so far as is known, this was the first industrial application of electron tubes in a field outside of radio, telephone, or telegraph communication.

THE CODE SYSTEM

THE DISADVANTAGES inherent in the use of steady energy led to the introduction of the code system in 1926. In this system, the train-carried apparatus is responsive to coded alternating current applied to the track circuit at its exit end and functions to maintain a continuous cab signal indication reflecting traffic conditions ahead of the train. To effect this response, the current in the rails is coded by interrupting it at certain rates, the number of interruptions per minute being determined by traffic conditions ahead. The absence of this track current or the presence of steady or uncoded current produces the most restrictive signal in the cab. The codes now generally used are 180, 120, and 75 interruptions or cycles per minute. The code pattern is uniform with the on and off periods of approximately equal length.

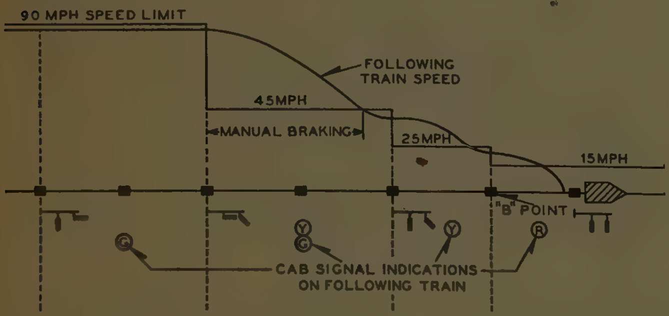


Figure 1. Changes in speed limits and cab signal indications as train approaches rear of train ahead

Voltages of the same frequency and code rate as t rail current are induced in the engine-carried receiv and these voltages are amplified to operate the coc following relay which governs the decoding units that a selectively responsive to the code rate at which the mas relay is operated. The decoding relays associated wi the decoding units in turn control the cab signals, t audible warning devices, and the electropneumatic valv

Coding of the rail current produces a number of i portant advantages not obtainable with the nonco system. These are:

1. The equipment operates safely in the presence extraneous currents or magnetic fields. It responds o to coded alternating current of the proper frequency.
2. No line wires are required for control of sign indications because the controls are transmitted by coc through the rails.
3. More than three indications can be obtained. fact, additional indications could be obtained by the u of other codes but four indications generally have be found sufficient.
4. Increased track shunting sensitivity and increas broken rail protection are obtained because code operati is determined by the pickup rather than the release val of the code-following relay.
5. It is universally applicable to any class of moti power, steam, Diesel, or electric locomotives and multip unit cars.

Figure 1 shows how the cab signal indication and spe control limits change on the modern 4-indication 4-spe control system selected as an example, as a train overtal a train ahead. Assume that the train is about to en the first of four blocks, the fourth being occupied. T cab signal is displaying the "clear" (green) indication a the maximum speed limit of 90 miles per hour is in effe As the engine passes the "clear" wayside signal, there no change in the cab signal or speed limit.

When the next wayside signal, at "approach-medium is passed, the cab signal changes to "approach-mediu (yellow over green) and the speed limit is reduced to miles per hour. The restrictive condition is made kno to the engineer by the sounding of a buzzer and, unl he initiates a manual brake application within six secon the brakes will apply automatically. As long as he applying the regular train brakes at the service rate, automatic application of the brakes is suppressed. must continue to maintain a service brake applicati until the speed of the train has been reduced below miles per hour, after which he can release the brakes a continue at a speed below 45 miles per hour until the n signal is passed. The buzzer will sound as long as the spe of the train is above the limit. The instant the sound the buzzer stops, the engineman may initiate release of brakes.

The speed limits of 90, 45, 25, and 15 miles per h have been chosen arbitrarily for the sake of illustrati While these may be considered typical, other speed lir may be selected by different railroads to suit their p ticular operating conditions.

hen the next wayside signal at "approach" is passed, cab signal changes to "approach" (yellow), the speed t is reduced to 25 miles per hour and the speed warning zer sounds and continues to sound as long as the speed above this value. As before, an automatic brake lication will be initiated within six seconds after the rspeed warning buzzer sounds unless it is suppressed by anual application sufficient to reduce speed below the limit.

ny time the speed limit is exceeded, the warning buzzer sound and continue sounding until the speed is reduced w the limit.

he next wayside signal will be at "stop" and it may be t the rear of the train ahead is just beyond the signal ation as it is shown to be in Figure 1. It may be ired, therefore, to effect the next cab signal change at the signal itself but at a point, called the *B* point, iciently in advance of the signal to insure that the train be stopped automatically from the maximum speed 25 miles per hour, before the signal is passed. As this nt is passed, the cab signal changes from "approach" 'restricting" (red) and the speed limit is reduced from to 15 miles per hour. Again the buzzer will sound and tinue to sound until the speed is reduced below 15 miles hour, and again an automatic brake application will ue if the engineman does not suppress it by applying brakes manually.

s an additional safety measure, any time the cab signal nges to "restricting" a bell will also sound and, even ugh the speed is already below the 15-mile-per-hour it, an automatic application of the brakes will be iated six seconds after the bell starts to sound unless engineman operates an acknowledging switch. This tch may be of either the foot-actuated or hand-actuated e. The purpose of enforcing an acknowledgment of the stricting" indication is to remind the engineman that he pproaching a "stop" wayside signal.

fter first coming to a full stop, in accordance with ndard railroad operating rules, the train may proceed the occupied block at a speed not exceeding 15 miles hour, being prepared to stop within range of vision.

Vhen the cab signal changes to a more restrictive ication, but the speed of the train is below the new it, the buzzer will not sound. Likewise, cab signal nges to indications less restrictive are unaccompanied sounding of the audible warning devices because block ditions have changed to permit operation of the train ly at higher speed.

EQUIPMENT ON THE WAYSIDE

HE APPARATUS used for operation of the continuous cab signal and train control system consists essentially wo main parts: one on the locomotive and the other on wayside.

he continuous indication in the cab is maintained by track circuit alternating current introduced into the ning rails at the exit end of the track section and interted a definite number of times per minute according he conditions ahead. This current induces a voltage apparatus carried on the engine and so causes other engine-carried apparatus to function to establish the cab signal aspect and speed limit corresponding to the frequency of interruption of the track current.

The mechanism in the wayside system which interrupts the alternating current as it is fed to the rails is called a code transmitter. One type consists of contacts actuated by an electrically driven pendulum mechanically tuned to the code frequency. A separate code transmitter is used for each code frequency.

The advantages of code control of cab signals apply equally well to the control of wayside circuits and signals. For that reason, the use of steady-energy track circuits for wayside signal control is fast being supplanted by coded track circuit control. The first coded track circuit control installation was placed in service in 1932 between Zoo Tower and Arsenal Tower on the Philadelphia Terminal Division of the Pennsylvania Railroad. There are now upward of 15,000 miles of track in the United States and Canada equipped with coded track circuits.

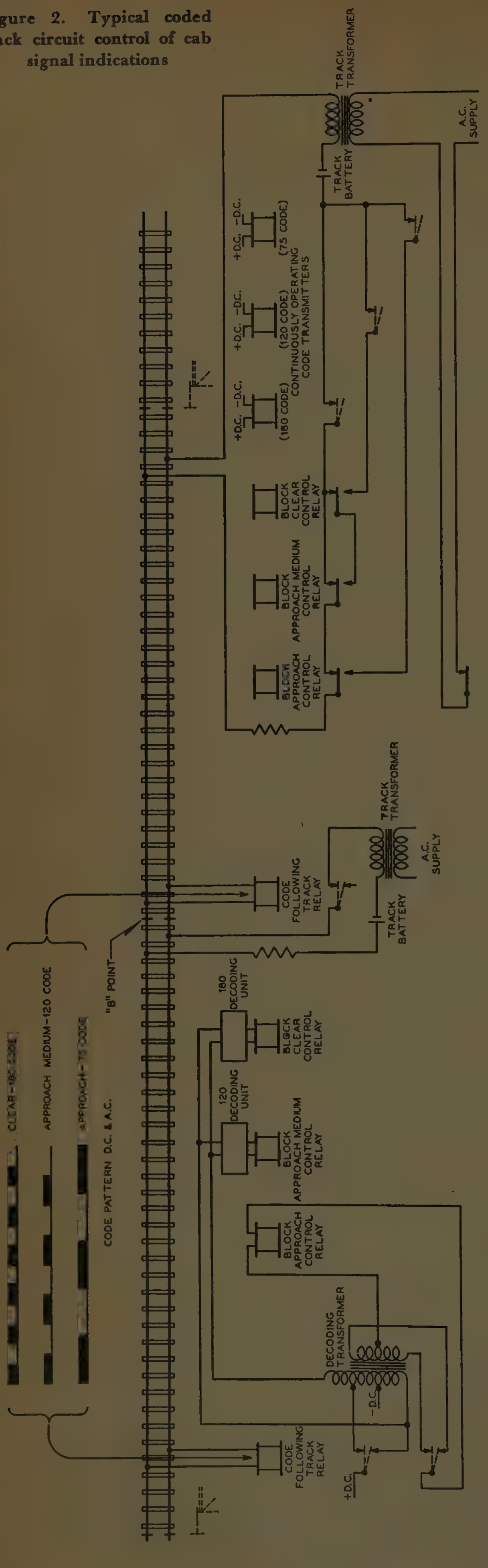
The foundation of all successful railway signaling is the track circuit. Invented in 1872, it still remains the best means yet devised of automatically detecting that a defined section of the railroad track is occupied or otherwise unsafe for the passage of another train. The rails themselves serve as the conductors of electric energy supplied by a low-voltage power source connected to the rails at one end of the circuit and delivered to the coils of the track relay connected to the rails at the opposite end of the circuit. Current is confined to the desired section of track by placing insulation in rail joints at the boundary points of the section. All other rail joints are bonded with flexible connectors to insure uniformly low resistance.

As long as the track circuit is unoccupied, all rails intact, and switches properly positioned, the track relay will receive energy and nonoccupancy will be indicated. The entrance of a train into the circuit, however, will shunt so much current from the coils of the track relay through the much lower resistance path of the wheels and axles of the train that the track relay will release and remain in its released position. This will cause the wayside signal to assume the stop position.

In considering the track circuit, it is important to note that a failure such as may be caused by loss of power, a broken wire, a broken rail, a misaligned switch or a short circuit will deprive the track relay of current, thus causing it to stay released and thus setting the controlled signal to its most restrictive indication. Not only the track circuit but all vital circuits in railway signaling are designed to operate on this "fail-safe" or closed-circuit principle. A circuit is said to be designed on the closed-circuit principle when the integrity of its vital elements is being checked constantly.

One typical form of coded track circuit control is shown in Figure 2. Both direct current from the track battery for operation of the code-following track relay and alternating current from the low-voltage winding of the track transformer for cab signal operation are coded over the same contact of the continuously operating code transmitter at the signal location. The code transmitted to the rear from the signal location is determined by the position of the

Figure 2. Typical coded track circuit control of cab signal indications



block control relays which, in turn, is dependent upon th code being followed by the track relay at that signal.

The block control relays receive energy from the d coding transformer. One contact of the code-followin track relay reverses the direction of direct current in th primary winding of the decoding transformer with eac operation of the code-following track relay. The cod frequency alternating current induced in the secondary the decoding transformer is rectified by a pole-changin contact on the track relay to cause unidirectional curre to flow in the winding of the block-approach control rela Only when the code-following track relay is operatin continuously will energy be induced in the secondar winding of the decoding transformer. If the code-followin relay stops, with either its upper or lower contacts close the supply of direct current to the block-approach contr relay is discontinued, and consequently this relay ope its upper contacts and closes its lower contacts. Und this condition, only 75-code direct current can be tran mitted to the circuit in the rear. Because the circu controlling the block-approach control relay is not tun or otherwise selective as to frequency, the block-approac control relay will be energized when the code-followin track relay responds to 180, 120, or 75 code.

Where more than one code is used, it is essential for th system to select between them. This is done by rela controlled from code-frequency selective decoding un connected to an auto-winding on the decoding transform Thus, the block-clear control relay responds only when associated decoding unit is receiving 180-code energy an the block-approach medium control relay responds on when its associated decoding unit is receiving 120-co energy.

These decoding units are similar to those used on t locomotive and will be described in more detail under description of the equipment on the locomotive.

Frequencies commonly used for the a-c supply are 6 80, and 100 cycles per second. The level of minimu alternating current under the receivers when the tra is at the entering end of the track circuit is usually of t order of 2.0 amperes where electric propulsion territory involved and 0.7 ampere elsewhere.

EQUIPMENT ON THE LOCOMOTIVE

IN FIGURE 3 is shown a schematic circuit plan of t locomotive electric apparatus for a 4-indication speed system, while Figure 4 shows in diagrammatic fo the pneumatic equipment which controls the initiation suppression of an automatic brake application.

The track receiver is the means by which the contro transmitted inductively from the rails to the apparatus the locomotive. It comprises a pair of laminated in cores and rubber-covered coils, one for each rail, moun ahead of the leading truck at an elevation of about ei inches above the top of the rails. The coils are connec so that the voltages induced in each are additive.

In series with the receiver is a capacitor for tuning circuit to the rail-current frequency, a tapped resistor sensitivity adjustment, and the input winding of the fil transformer. The output winding of the filter transform

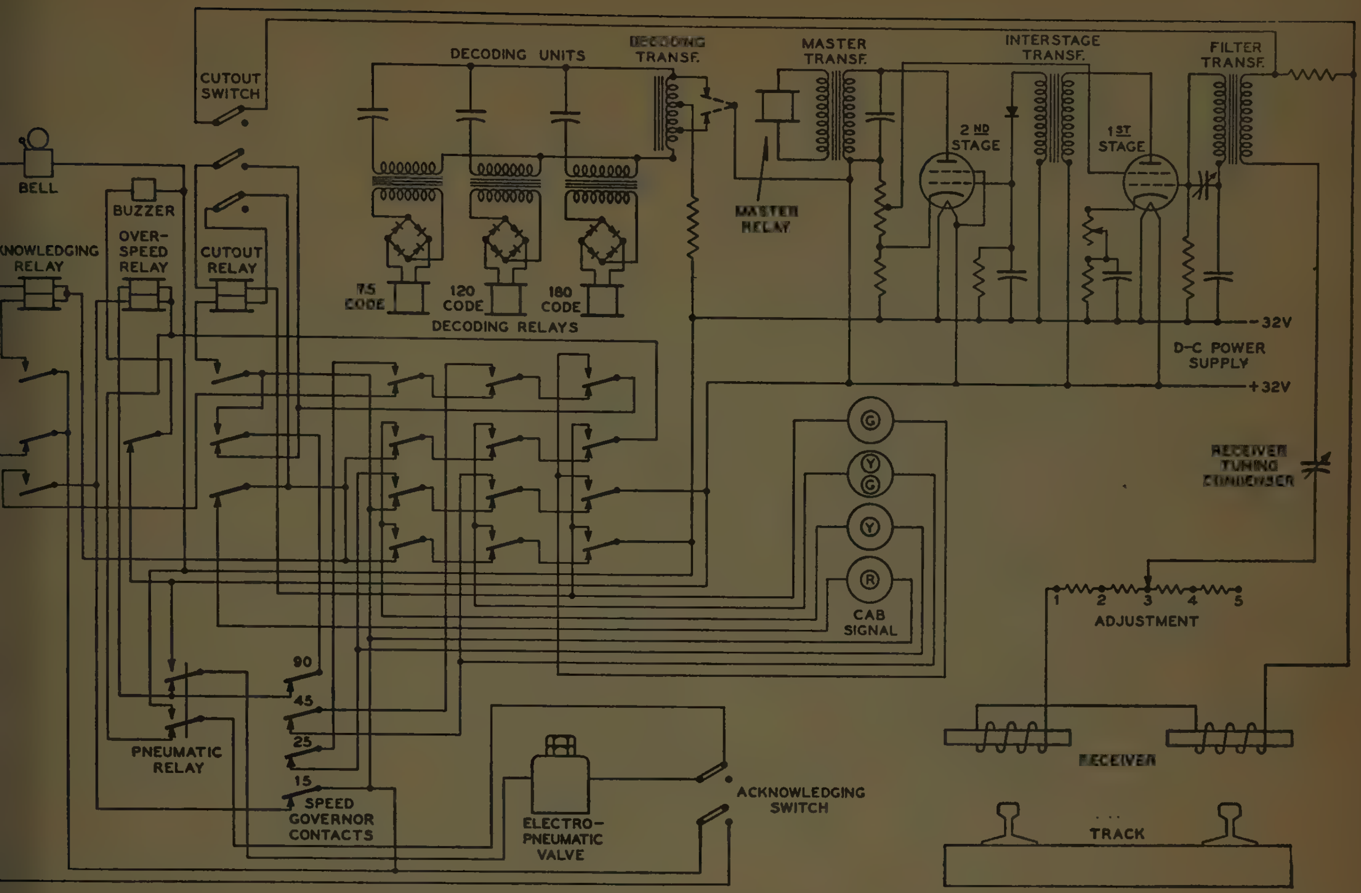


Figure 3. Circuit of electric equipment on the locomotive

o is tuned to resonance at the rail-current frequency provide sharp discrimination against frequencies outside e desired bandwidth.

The amplifier contains two identical beam-power tetrode cuum tubes with indirectly heated oxide-coated cathodes. ıese tubes were especially designed for locomotive service operate from the regular 32-volt d-c supply. No dyna- ptor or other high-voltage plate supply is required. The pes have a maximum rated transconductance of 6,800 cromhos.

Two stages of amplification are shown in Figure 3. In e first, the voltage output of the filter is increased by ass-*A* amplification and the interstage coupling trans- mer. The second-stage tube action is that of a d-c nplifier. The copper-oxide rectifier causes only the sitive half-cycles of voltage from the interstage transformer be applied to the control grid of the second-stage tube. ne capacitor between grid and the −32-volt line is arged to substantially the peak value of the positive lf-cycles of voltage. A resistor in parallel with the pacitor allows the charge to leak off during the off riods of code, but not during the negative half-cycles of ernating current. The second-stage tube is biased to cutoff point.

Thus, during the off period of the code cycle, no current ws in the plate circuit of the second-stage tube. During on period of the code cycle, when current is flowing in rails, the plate current rises to a value determined by potential difference between the positive charge on the grid capacitor and the fixed negative grid bias. The result is that plate current flows in the primary of the master transformer when alternating current is flowing in the rails and ceases to flow when the rail current is interrupted by the code transmitter.

The rise and fall of plate current in the high-voltage winding of the master transformer causes alternating current of code frequency to flow through the low-voltage winding and the master relay connected to it.

The master relay is of the d-c polarized stick type; that is, its armature will be held by the permanent magnet in whichever position it occupied when last de-energized. With alternating current of code frequency in its coil, the relay is periodically energized in opposite directions and, therefore, the contacts move from one position to the other at the code frequency. The relay thus responds to code-frequency current only when this has a value greater than a predetermined minimum and its contacts thus are held firmly closed by the permanent magnet in one position or the other except during reversals of current.

When the master relay is operating, it causes direct current from the 32-volt supply to flow alternately through one half or the other half of the primary section of the decoding transformer, causing the magnetic flux of this transformer to alternate in direction at the code frequency and thereby deliver alternating current to the decoding circuits.

The output of the decoding transformer is applied to three tuned decoding units in parallel. Each decoding

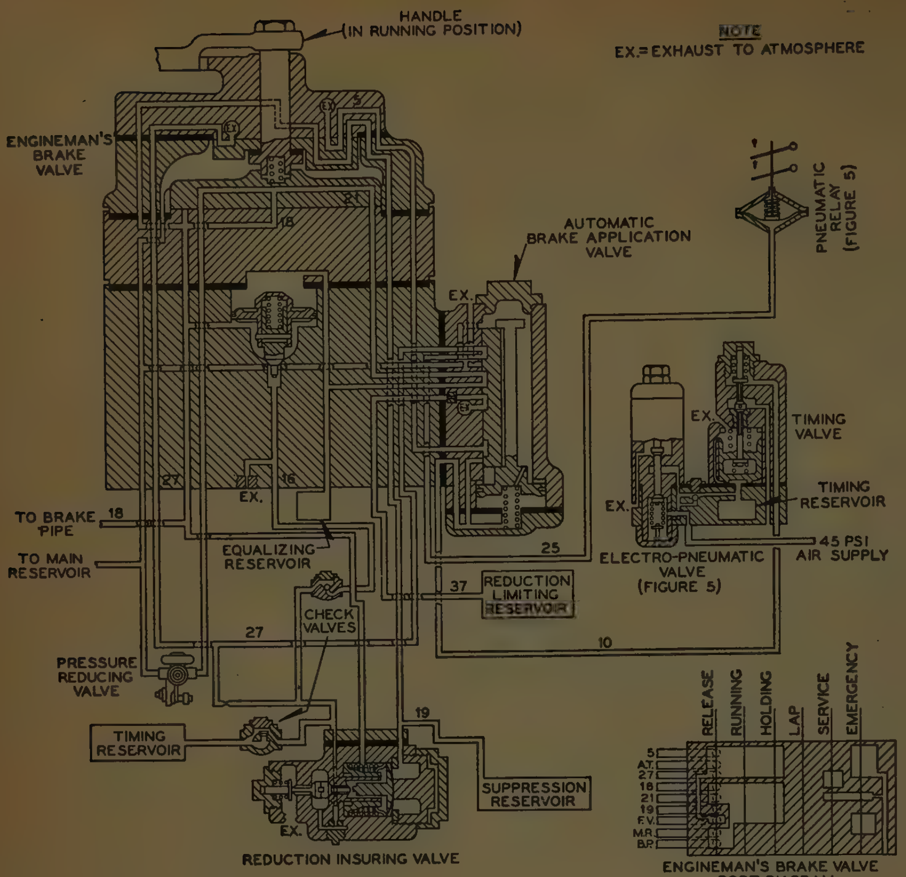


Figure 4. **Pneumatic equipment piping diagram**

unit is a low-frequency filter tuned to resonance at one of the three code frequencies. Each consists of a capacitor in series with the primary of an adjustable-air-gap reactive transformer having its low-voltage winding connected through a double-wave copper-oxide rectifier to its associated decoding relay. The 180-code decoding relay thus will respond only when the voltage applied to its associated decoding unit has a frequency of 180 cycles per minute or three cycles per second. Likewise the 120-code decoding relay is responsive to 2-cycle energy from the decoding transformer and the 75-code decoding relay to $1^1/_4$-cycle energy.

The tuning of circuits to resonance at such low frequencies is uncommon in the field of electrical engineering. Typical curves showing the variation of decoding relay current with code frequency are shown in Figure 5. These curves show that the "clear" decoding relay will not receive enough current to hold its armature closed on 120 or 75 code and the "approach-medium" decoding relay will not receive enough current to hold its armature in the energized position on 75 code. A part of the selectivity obtained in the decoding circuits is due to the nonlinear voltage-current characteristic of the copper-oxide rectifier. Since each decoding circuit is series resonant, selectivity on the upper side of resonance is less than on the lower side. This is not important here, however, because the contacts of decoding relays responsive to one code frequency are not involved in the control of circuits associated with a higher code frequency.

The train control circuits are carried through relay contacts in both the positive an negative sides of the d-c paths t prevent, as far as possible, imprope operations caused by grounded wiring or short-circuited terminals.

Through the use of the cutou switch and its associated cutout relay, the train may move out c train control equipped territor without reducing speed and th equipment will be conditioned fo automatic restoration of the control upon re-entering train control territory at any point. To accomplis this, a short stretch of track, a certain designated points of departure from equipped territory, is energized with 180-coded alternatin current of several times the norma value. While the receiver is traversing this track section, the engineman reverses the cutout switc and holds it reversed until passag of the end of the cutout circuit is indicated by loss of cab signal illum nation. Reversal of the cutou switch energizes one coil of the cu out relay over a normally ope contact of the switch and the uppe contacts of the 180 decoding rela At the same time, enough resistance is added to the r ceiver circuit to prevent master relay operation excep at the high level of alternating current used in these cutou circuits. This prevents a cutout being effected at a but an authorized location. As soon as the receiver pass the end of the cutout circuit and the "clear" cab indicatic is extinguished, the engineman must restore the cuto switch to its normal position quickly in order to establis the holding circuit to the other coil of the cutout rela through the lower contacts of all decoding relays, an upp contact of the cutout relay, and a normally closed conta of the cutout switch.

As long as the cutout relay remains energized, th 15-mile-per-hour speed limit, normally in force with a decoding relays down, is raised to 90 miles per hour. A the train again enters train control territory and any o of the three decoding relays is energized, the circuit to th cutout relay will be opened and all control circuits restore to normal.

On some train control installations the cutout function performed automatically by coding the current in th cutout circuit at another code frequency and energizi the cutout relay from an additional decoding unit tuned this frequency.

When the cab signal changes to "restricting" and the b rings, the acknowledging relay is energized by the revers of the acknowledging switch in much the same mann as just described for the cutout circuit.

Figure 4 is a schematic diagram of a typical set of pne matic equipment and shows only that portion direct volved in the initiation or suppression of an automatic ain control brake application. The position of the rious valves is shown at that instant just after the timing lve has reversed, due to de-energization of the electro-neumatic valve six seconds before, and just before reversal the brake application valve. As its name implies, the ming valve with its reservoir measures a time interval of seconds within which the engineman may take the tion required to prevent an automatic application.

If this action is not taken, the air chamber below the ake application valve piston will be exhausted through pe 10 and the upper timing poppet valve. This causes e brake application valve to shift downward and in so ing to produce the same result as if the engineman's ake valve handle had been moved to the service position r a definite period of time. Reduction of brake pipe pres-re will continue until equalization of pressure in the ake pipe, the equalizing reservoir, and the reduction niting reservoir occurs.

Upon re-energization of the electropneumatic valve and ovement of the engineman's brake valve handle to "lap" sition for a short time, the brake application valve will turn to normal after which the brakes may be released the usual manner.

It should be noted that the control of the air brakes on railway train is also on the closed circuit principle. The akes are held released by maintaining air pressure in the ake pipe which runs throughout the train and is coupled tween cars by flexible hose. To apply the brakes, the gineman moves his brake valve handle to service position d allows air to escape from the brake pipe. The re-uction of pressure in the brake pipe actuates valves on ch car to admit air from a reservoir to the brake cylinders. hus, any loss of air pressure in the brake pipe, such as by broken air hose, will cause the brakes to be applied mediately throughout the train.

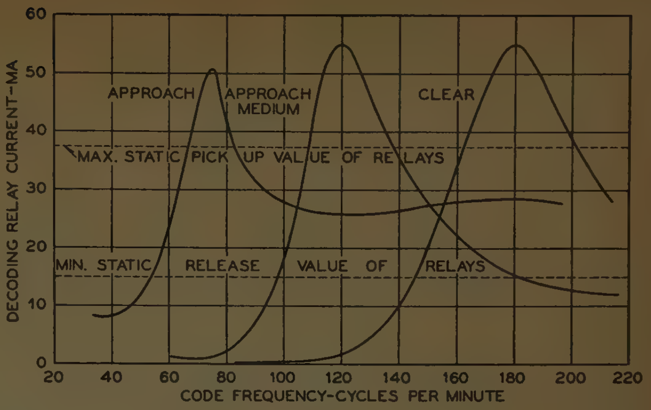


Figure 5. Variation of decoding relay current with code frequency

Any time the engineman moves his brake valve handle to service position, prior to an automatic application, air pressure is applied to the pneumatic relay through pipes 18, 27, and 25. Operation of the pneumatic relay applies energy directly to the electropneumatic valve. After brake pipe pressure has been reduced a predetermined amount, the reduction insuring valve will move to the left and stop the exhaust of air from pipe 27. This will permit the engineman to move his brake valve handle to "lap" position without loss of air pressure in pipe 25. In this manner, automatic control of the train brakes is suspended as long as the engineman is properly handling the braking system himself.

REFERENCES

1. Interstate Commerce Commission Report (Washington, D. C.), January 1, 1950.

2. The Signal in the Cab. *Bulletin 144*, Union Switch and Signal Company (Swissvale, Pa.).

3. Coded Cab Signals. *Bulletin 171*, General Railway Signal Company (Rochester, N. Y.), October 1937.

4. Description of Continuous Inductive Train Control Systems of the Union Switch and Signal Company. *Bulletin 8*, Committee on Automatic Train Control, Association of American Railroads (Washington, D. C.), January 1931.

5. Cab Signaling and Train Control on the San Francisco–Oakland Bay Bridge. *Railway Signaling* (Chicago, Ill.), May 1939, pages 274–9.

New Shuttle-Bonding Technique Gives Longer Life

Weaving shuttles, traditionally made of dogwood or rsimmon wood for high impact strength and retention of nooth contours for long periods of continuous operation, n have longer life by surfacing the shuttle on two or more des with hard fiber sheet. Electronic dielectric heating chniques have been adapted to shuttle bonding to im-rove the quality of the bond, reduce its cost, and increase oduction. Use of a radio-frequency generator for ating plus an automatic hydraulic press, which gives niform pressure on both the straight and curved portions the shuttle face, produces a uniform bond the length of e shuttle—a bond that will withstand the hard impact the picker stick as it drives the shuttle across the loom.

The old method generally involved the use of a casein ue to coat both the fiber and wood surfaces on two opposite uttle sides. The new technique uses stray field heating, with electrodes embedded in rubber on the surface of thick rubber dies, to heat the glue line for the purpose of polymerizing the thermosetting plastic glue used with the new process. A radio-frequency generator supplies the required dielectric heat at a frequency of approximately 13.6 megacycles. A standard steel die set, used in a hydraulic arbor press, makes up the upper and lower platens on which are mounted the electrodes and rubber dies.

The total curing time required is only 90 seconds, compared to previous methods requiring four hours or longer for thorough glue setting. The time saving is actually greater than the 90 seconds indicate, since more than one shuttle can be bonded simultaneously. Glue savings up to 75 per cent have resulted, since the radio-frequency technique is critical of the amount of glue used.

Commutation in Universal-Type Motors

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IN COMMUTATOR-type motors, the current is reversed in the armature coils as the commutator bars, to which they are connected, pass under the brushes. During the period of reversal the coils are short-circuited due to the brush making contact with two bars to which the ends of the coils are connected. The current in the short-circuited coil is determined by the voltage which is generated in that coil and the resistance of the coil, brush, and brush contact.

In the d-c series motor, there are three voltages generated in the short-circuited coil. One is due to the armature flux which crosses from slot to slot, another is due to the combined magnetic field produced by the field and armature windings (this magnetic field is in the space between the poles), and another due to the flux set up in the armature end winding in the zone of the short-circuited coil. The short-circuited armature coils cutting across these three fluxes generate these short-circuit voltages, the values of which are proportional to the flux cut by the armature conductors, the revolutions of the armature, and the number of turns in series. These voltages will be referred to as rotational voltages. They are also generated in the a-c series motors in addition to a voltage generated by the reversals of the main field flux just as the voltage is generated in the secondary winding of a transformer.

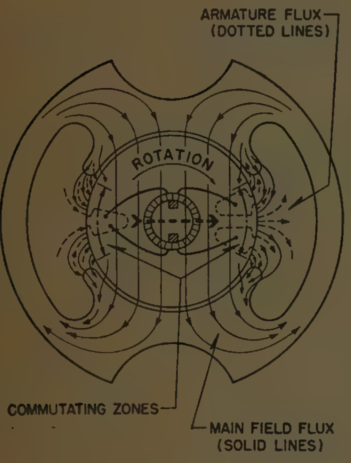

Figure 1. Diagram of main and armature flux in a noncompensated universal-type motor

Figure 1 shows the path of the main field flux and that of the armature flux, and also the location of the armature coils which are short-circuited by the brushes. It can be seen that the whole main field flux passes through the coils while they are short-circuited. Therefore, with alternating current, the transformer voltage then is proportional to the number of turns in the armature coil, the total main field flux, and the frequency of the circuit. The transformer voltage is 90 degrees out of phase with the field flux; its value is independent of the speed of the armature.

Referring again to Figure 1, it will be noted that th short-circuited coils are moving through a magnetic fiel which is produced by the combined flux from the field an armature. The armature flux is indicated by dotte arrows. The commutating zone, as indicated, represent the space through which one or more short-circuited coil move. It is the flux within this space which concerns u in considering commutation. The value of the flux in th commutating zone is determined by the ampere-turns c the field, the ampere-turns of the armature, and the reluctance of the magnetic path. With the brushes on neutral, the reluctance of the magnetic path is high in th center of the commutating zone and decreases to a comparatively low value at the pole tips. The reluctance i the commutating zone is changed with the shifting of th brushes because the relative position of the brushes an commutating zone remains constant.

The rotational voltages are in phase with the field flu and are 90 degrees out of phase with the transformer voltag in the short-circuited coil and for that reason cannot in an way affect the value of the transformer voltage. The rotational and transformer voltages are added vectorially.

Shifting the brushes against rotation corrects only th condition produced by the rotational voltage, but, in combination with armature and field strengths proportione to reduce the field in the commutating zone in noncompensated Universal motors, will improve commutation.

A ratio of armature to field strengths in the order of 0. to 0.8, together with a brush shift of 20 to 26 electrical degrees, depending upon the field form, in a 2-pole motor wi give good commutation and brush life. The brush shift wi depend somewhat upon the ratio of pole face to pole pitc and the chording of the armature winding and the ratio c the armature to field winding.

Compensated motors have slotted primaries in which th main field is usually a single coil. The armature field compensated by a distributed field winding in series wit the armature but opposing the armature field and at 9 degrees to the main field. This compensation leaves onl the transformer voltage to deal with in regard to the shor circuit current in the armature coil being commutated o alternating current. The single-field compensated moto is similar to the motor which was just described, except tha the compensation for the armature field is obtained b shifting the brushes sufficient to fully compensate for th armature field.

It is desirable to keep down the total value of the shor circuit voltage to five to seven volts per brush and th short-circuit current to a minimum, at the full load poin

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Digest of paper **51-24**, “Commutation in Universal-Type Motors,” recommended the AIEE Committee on Rotating Machinery and approved by the AIEE Technic Program Committee for presentation at the AIEE Winter General Meeting, New Yor N. Y., January 22–26, 1951. Scheduled for publication in AIEE *Transactions*, volu 70, 1951.

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The Use of Electric Power in the Petroleum Industry

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MEMBER AIEE

This article discloses the total power required to perform all the operations of the four principal phases of the petroleum industry, drilling, production, transportation, and refining. All power requirements are reduced to electric energy equivalent of the kilowatt hour. The ratio of "purchased" to "generated" electric energy also is shown.

THE PETROLEUM in- dustry requires large amounts of mechanical ver and application of t in its various phases or isions in passing from the covery or exploration stage he delivered refined prod- in your automobile. It argely an industry built und the use of a certain mechanical device, the pump. The scope of this discussion, however, is limited to electric plication, and since the use of electric power is tied in so sely in an economic sense with the other forms of me- nical supply, some mention has to be made occasionally indicate why the choice was made to use electricity. e reason for this is that essentially the oil industry is a ducer of energy in itself in a form suitable to perform all mechanical functions used in its production, so the question may be asked why should it look elsewhere for an energy supply which requires conversion of their own products into electricity, with the consequent inherent conversion losses, which in turn will only perform the mechanical functions of pumping, their original principal operating business. The answer is that in recent years electric power has been shown to provide better positive and/or automatic control of equipment, higher possible speeds in motive power, provide smaller investments in pumps, less space is required to be occupied, and, finally, electric power is a great labor and maintenance saver over the other methods. These are the principal reasons for the broad acceptance of electric power by the oil industry.

The United States petroleum industry in 1950 in its far-flung operation drilled about 38,000 wells, produced approximately 1,800,000,000 barrels of oil, practically all of which will be transported to refineries, and then refined for use. A careful estimate of the amount of power energy to perform these functions is shown in Table I.

Thus, it is seen that the petroleum industry requires about 27,000,000,000 kilowatt hours of power, or its equivalent, for performing its complete operation from oil discovery to supplying filling stations and other general industry (see Figure 1).

In its various phases it can be noted that well drilling requires 10 per cent, producing 27 per cent, transportation (pipelines) 18 per cent, and refining 45 per cent of the total power. The refining industry also requires about 18 times

ble I. **Equivalent Kilowatt Hours Required by Four Phases of Petroleum Industry**

(Basis, 1949 Production in the United States)

Function	Total Equivalent Kilowatt Hours for Operation
ing 38,000 Wells	
cable tool, 2,500 feet average depth	450,000,000
rotary method, 3,440 feet average depth	2,200,000,000
l for drilling	2,650,000,000
lucing	
,615,000 barrels from an average depth of 3,000 feet; 449,545 ells; 51,240 flowing wells at 11.1 barrels per day with a 2-to-1 ter-to-oil ratio, 1.5 kilowatt hours (kwh) per barrel of fluid ted	7,300,000,000
lines	
le:	
500,000,000 barrel-miles pumped—trunk lines (1948); 140,000 horsepower; 0.007 kwh per barrel-mile	3,600,000,000
ned Products:	
973,000,000 barrel-miles pumped (1949); 267,000 horsepower; 007 kwh per barrel-mile	760,000,000
hering lines, each barrel pumped 51 miles average	400,000,000
not include gas pumping of 1,200,000,000 kwh in Big Inch es	4,760,000,000
neries (basis 1944 extended)	
,254,000 including imports (103,639,000 barrels)	380,000,000
,615,000 barrels produced in the United States 3.7 kwh per rrel (electrically)	6,800,000,000
hanical power 36%, 2.1 kwh per barrel (steam and internal mbustion engines)	4,080,000,000
ral gasoline plants (100,000,000 electrically, balance gas engines)	1,100,000,000
	12,360,000,000
nd Total Equivalent Electric Energy Required	27,070,000,000

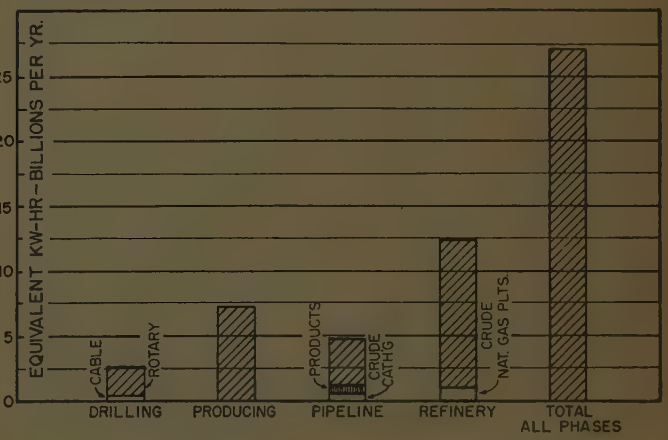

Figure 1. **Power requirements of the petroleum industry (see Table I)**

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ntial text of a conference paper presented at the AIEE Fall General Meeting, ober 23–27, 1950, Oklahoma City, Okla.

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its mechanical motive power heat unit requirements in the form of oil or gas for distillation purposes; all obtained from its products or by-products.

Table II shows the amount of electric power (generated and purchased) which is consumed by the four various phases of the petroleum industry, along with the percentages of electrification based on actual energy consumed as related to the total amount of energy required. Also shown with proper documentary authority is the relation between generated and purchased power required, based on the horsepower and assumed load factor of equipment installed, or on the number of units in use, as in the case of drilling phase of the industry (see Figure 2).

Table II. Electric Power Requirements of Petroleum Industry

Function	Per Cent Electrified	Generated & Purchased Power Used, Millions of Kilowatt Hours	How Electric Power Is Obtained, Per Cent	
			Generated	Purchased
Drilling[1]	4*	106	76	24
Producing[2]	22	1,600	15	85
Transportation[2]	46	2,200	2	98
Refining**[3]	59	7,280	35	65
Totals	41	11,186	25.5	74.5

* D-C and A-C.
** Includes natural gasoline plants.

The results shown in Table II show that the entire petroleum industry is 41 per cent electrified, based on t amount of electric power consumed by all phases of su industry. Utility sales of electric energy approach 8,30 000,000 kilowatt hours, whereas the amount generated the oil industry approximates 2,800,000,000 kilowatt hou It can be noted that the lowest use of electric power pr vails in the drilling phase, due to the far-flung and remo location of the operations. Next in use of electric power the producing phase, and again the same reason can given for the relative low electric usage; leases are genera remote from utility power lines, and the very nature of t operation beginning with the discovery may require th wells be pumped early, but the extent of the developme cannot be determined; therefore, the easiest method is use fuel gas from the well and install an engine, and order to have uniformity in equipment, the second well is equipped, and so on, until the whole leashold is produc with engines. Note that where large quantities of pow are required in fixed localities, such as in the pump st tion and in the refinery, the use of electric power is rel tively greater. However, the remoteness of pump static locations sometimes makes the use of engines imperativ Refineries are generally even more electrified than pumpi plants; they are usually located near power lines of pop lation centers, thereby accounting for the greater percenta of electrification of the refinery (46 per cent versus 59 p cent).

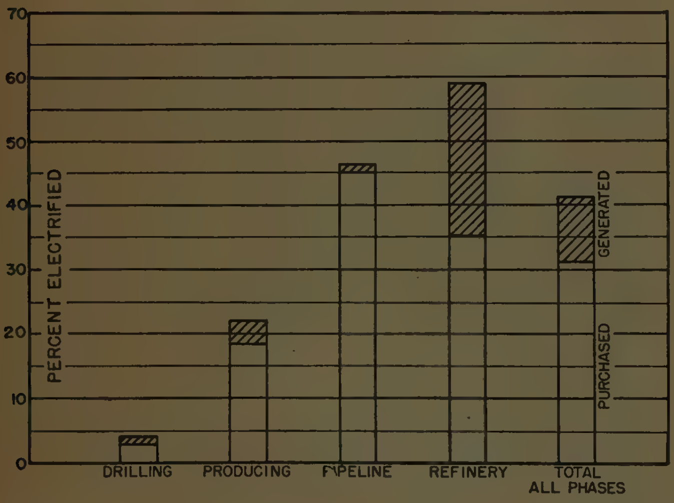

Figure 2. Extent of electrification of the petroleum industry (see Table II)

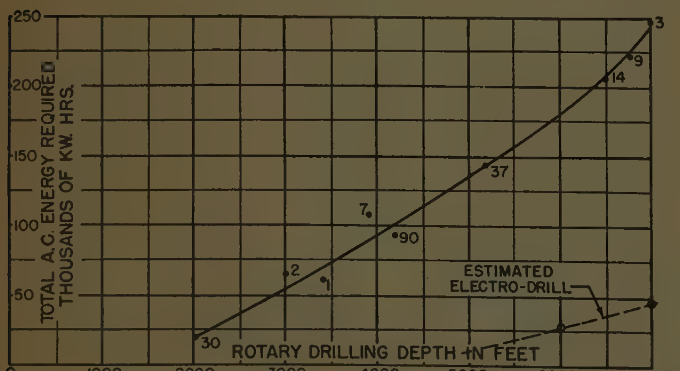

Figure 3. Total electric energy required to complete oil wells drilled with rotary tools (195 wells)

OIL WELL DRILLING

As discussed previously, the drilling or exploration f oil is the smallest user of electric power, since there a so few rigs on hand equipped with motors. Rigs equipp with a-c motors, perhaps 75 in number, are usually found localities where utility power lines are readily availab such places as in West Texas, where a 13-kv power line installed in a proved field, and the drilling unit, substatio and derrick are all skidded from one completed well 6 feet to the next location, and most of the energy readin were obtained from this sort of operation. Service is d livered at 440 volts and the kilowatt-hour meter registe the total electric energy delivered to the machinery-drilli stand and mud pump. The rate of power taking also registered on the demand chart, and this is an important fa tor in studying the performance of drilling machinery. is almost impossible to obtain this sort of information fro steam or internal combustion engine equipment in the fiel A-c electric power has been generated in the field in only few instances; however, d-c power has to be generated the field, and its use is generally applied to the off-sho drilling units in the Gulf Coastal areas.

In 1949 "wildcat" drilling accounted for 9,058 wells bei drilled, or approximately 24 per cent of all the wells drill in that year. The average depth of each well was 3,8 feet or 12.5 per cent greater than average well drilled wi rotary tools (see Table I). This accounts for the drilli contractor's general acceptance of the mechanically power rig, since he is able to use such equipment in proved fiel as well as for wildcat exploratory drilling. Figure 3 shown for the purpose of illustrating the amount of electr power consumed by a-c rigs as the upper curve, whereas t r curve is estimated as being indicative of the power re- ements of a recent development in the application of ric drilling power at the well bottom. The unit is vn as "Electro-Drill" and consists of a 17.5-horsepower volt 3,600-rpm motor geared to 265 rpm, the speed of oit; all suspended on a cable. This unit has been used nsively for obtaining "cores" or samples of oil for- ions, but is designed for the complete drilling operation. ill drill at an average rate of 12 feet per hour, with power e of 2 kilowatt hours per foot to drill, and 2 kilowatt rs per foot additional for cleaning out cuttings in wells 0 feet in depth, whereas for wells 10,000 feet deep, the er remains at 2 kilowatt hours per foot for drilling, but cleaning out will average 7 kilowatt hours per foot. e in Figure 4 the total electro-drill power for wells 0 to 11,000 feet deep. A generating unit of only 75 would be required, since the drilling load is about 25 and cleaning out load is 50 kw when lifting cable rate is feet per minute.

n Figure 3, numbers represent the number of wells aged from data compiled from the record of 195 wells led with rotary tools. The curve is plotted through the age kilowatt hours for the number of wells drilled to that th.

igure 4 is shown as reflecting the increase in energy re- ed to drill wells in the 10,000- to 11,000-foot depths. e that the extended curve from 7,000 feet, if plotted at same slope, falls between the points for the ten wells led at 10,000 and 11,000 feet, thereby lending consider- weight to the data collected for the greater depths.

he total electric energy shown in Figure 4 can be used letermine the amount of fuel required if internal com- tion mechanical or steam driven drilling rigs are con- red. For the mechanical rig, after all factors of down- e are considered, including changing bits and loading of ntable engines at various stages of depth, about 20,000 per kilowatt hour would be required as fuel, whereas a steam rig with engines and pump power exhausting tmosphere, approximately 50,000 Btu per kilowatt hour ld be required under similar conditions. The motors l by the a-c rigs are of slip-ring (variable-speed) class rovide high torque to gain acceleration from stand-still dition.

OIL PRODUCTION

HERE ARE about ten methods used by the petroleum producer in achieving production, variations of pumps ll types, gas lifting, and gas or water flooding. How- r, only five of these methods in a broad sense lend them- es to using electric power. Table III lists these five hods, along with the limitations of capacity and depth of ducing horizon and power required (minimum and imum).

able III merely states the conventional methods gener- employed by the oil producer in field practices, and uld not be used for determination of actual horsepower, only for practical limitations in equipment sizes gener- available.

s this producing phase of the industry is only 22 per t electrified, including the purchased utility and self-generation requirements, it offers perhaps the greatest potential opportunity for electrification of the petroleum industry operations.

Table III. Production Methods Generally Susceptible to Electrification

	Depth of Well, Feet		Fluid, Barrels per Day		Horsepower	
	Min.	Max.	Min.	Max.	Min.	Max.
Beam pumping (individual)	600	10,000	1	500	3	100
Central power (groups 5 to 25)	600	2,500	1	25	1	5
Centrifugal bottom hole	1,500	6,000	1,000	3,000	25	200
Hydraulic bottom hole	2,500	10,000	50	400	10	50
Water flood	600	3,500	10	100	3	25

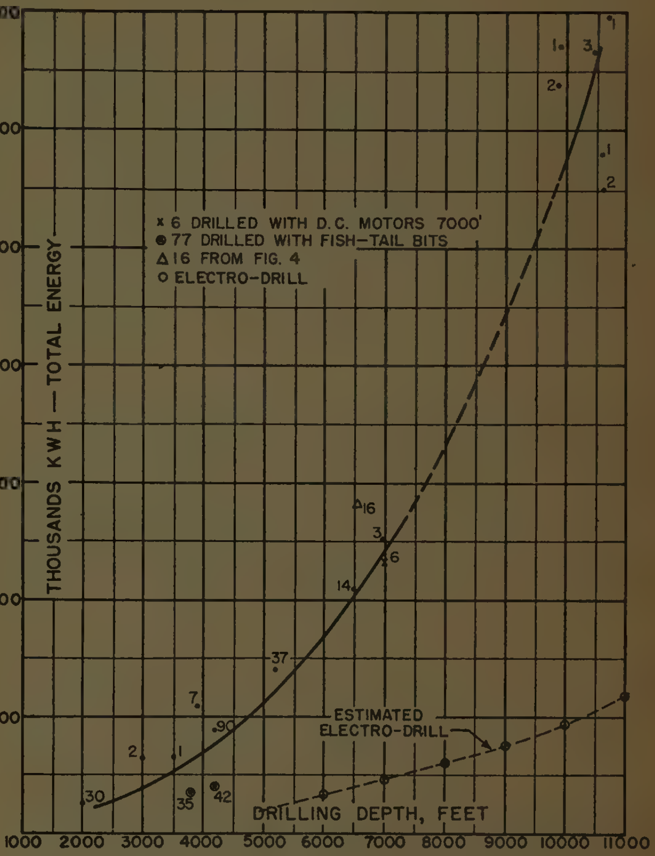

Figure 4. Electric energy required to complete oil wells drilled with a-c motors—rotary method

Figure 5 is offered to assist the oil producer in selection of properly rated motor or engine based on the amount of production desired. The readings are assembled from power data taken from almost 2,000 wells pumped with the five accepted methods shown in Table III. The "Max" line represents equipment whose over-all efficiency is 28 per cent, and the "Min" line represents equipment with over-all efficiency of 48 per cent. Somewhere between these two values, probably the "Mean" line (36 per cent efficient) can be used in determining the power capacity of the prime mover. The type of pumping equipment used seems to follow the accepted practices mentioned in Table III, as central powers are used principally for relatively shallow depths (2,500 feet and less), whereas individual pumps are used between 2,500 and 4,500 feet and the centrifugal and hydraulic bottom hole pumps are used for the deeper wells (5,000 to 6,500 feet). Depth of wells, however, does not always influence the choice of equipment, since the volume to be produced also has to be considered. Thus, a well 6,500 feet deep may be capable of producing only a small amount of oil in such quantity that a beam pump would prove more advantageous. In the case of horsepower determination for individual beam pumps, care should be used to increase the horsepower rating of the motor about 50 per cent over that calculated from the curve or "Mean" value.

In these days operating labor is a big factor in lease expense, and generally electric equipment can be operated for about 40 per cent of that labor required for internal combustion engine operation, which makes the use of purchased or generated electric power of economic merit. The choice of source of electric power then resolves itself into the projected life of the field. In many cases oil production will decline to such low values so quickly that generation is not considered. Normal declines in productivity drop to 20 to 30 per cent of original capacity in eight to ten years.

PIPELINE PUMPING

THE USE of electric power for this service has increased rapidly during the previous ten years, and perhaps the greatest stimulus was given during World War II, when electric motors were used for the Big and Little Big Inch Pipelines. About 225,000 horsepower of motors were installed on both the 24-inch and 20-inch lines. Amazing efficiencies were obtained from the equipment, 86 per cent on the pumps and 94 per cent on the motors, or over-all per cent. A barrel of oil required about 0.5 kilowatt ho to pump it 100 miles through these lines at an average c of only 4 mills. Since the war's end in 1945, practically per cent of all prime movers installed on pipelines have be motors. Since the larger proportion of older crude lines are 8, 10, and 12 inches in diameter, a safe figure power requirement to pump oil is somewhat greater th achieved in the 24-inch Big Inch line, probably of the ord of 0.7 kilowatt hour per 100 miles.

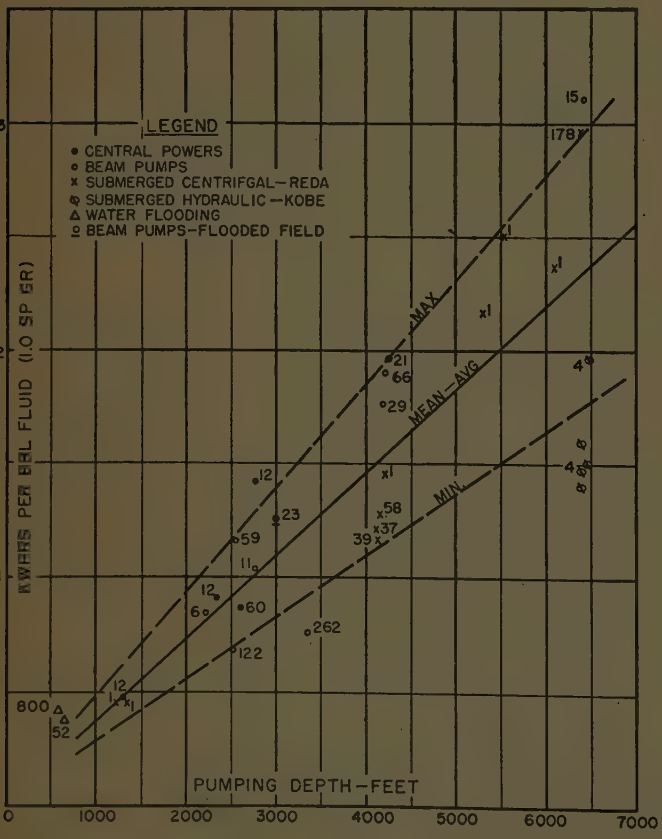

Figure 5. Electric power required to pump oil wells

The accepted practice today is to install induction mot of 1,800 to 3,600 rpm directly connected to centrifu pumps. In some cases synchronous motors have been use principally attached to plunger pumps, where the sl speed of the motor (327 rpm) made its adaptation to t slow-speed pump (50 rpm) good mechanical practice fr a gear-ratio standpoint. Electrically, however, the e ciencies and power factor of the induction motor in si considered are practically equal to the synchronous-ty motor, when considered from the viewpoint of investme safety, and starting apparatus required in each ca Utility rate practices generally do not offer sufficient bo for power factor improvement to justify the synchron motor over the induction type. In cases of a "wea power system, capacitors generally can be installed with t induction motor much cheaper than having the capaci effect built in the synchronous motor.

Many years of experience in attempting to secure t electrification of pipeline stations, brought these factors the forefront, supposedly favoring the Diesel engine:

1. Pipelines operate at 100 per cent capacity factor all times, year after year.
2. Pumping energy could be produced with engi for the fuel cost only of the oil in line.
3. Electric power was dangerous and unstable from continuity standpoint.
4. Maintenance and operating labor are the same wh ther Diesel engines or electric motors are used.
5. Stand-by units are required with either type of pri mover.

A study of six totally electrified pipelines was made a the results are shown in Tables IV and V. Table column 5, shows that the capacity factor is less than 100 cent.

When the capacity factor is less than 100 per cent, pov usage falls off percentage-wise as the square of the capac factor when expressed as per cent of maximum desi through-put. This materially affects the electric operati expenses as power costs decrease rapidly since the unit c per kilowatt hour is about four times that of fuel costs the engine.

Electric power is not dangerous and very few accide are recorded in electric pump stations because of failure wiring or switch equipment. The best evidence of conti ity of power service is in the case of the Big Inch system n converted to natural gas pumping. These lines are sho in Tables IV and V as *E—20* and *F—24*. They w served by some 20 utilities, passed through nine states, a the shutdown time due to power failure was only 0.12

Table IV. Description of Totally Electrified Pipelines Studied

eline	Data Years	Number of Stations	Type of Pumps	Motors Type	Motors RPM	Design Capability, Barrels per Day	Nominal Station Horsepower	Length, Miles	Pipe Diameter, Inches
	7	4	Centrifugal	Induction	1,800*	40,000	800	130	10
	4	3	Plunger	Induction	600	36,000	600	191	10
	3	14	Centrifugal	Induction	3,600	95,000	1,800	455	12
	5.75	6	Plunger	Synchronous	327	60,000	1,000	168	12
	1.5	29	Centrifugal	Induction	3,600	235,000	3,750	1,454	20
	1.66	26	Centrifugal	Induction	1,800	330,000	4,500	1,254	24
							262,000		

hanged to 3,600 rpm after assembly of data.

Table V. Actual Deliveries and Energy Consumed for Six Electrified Pipelines

eline	Data Years	Maximum Possible Through-put, 1,000 Barrels	Actual Barrels Pumped, 1,000 Barrels	Average Capacity Factor, Per Cent	Maximum Possible Energy Required, 1,000 Kilowatt Hours	Actual Energy Consumed, 1,000 Kilowatt Hours	Average Per Cent Electric Usage Actual	Average Per Cent Electric Usage Theoretical
	7	102,200	81,439	79.5	147,168	91,763	62.1	63.4
*	4	52,560	43,395	82.5	42,800	26,553	62.2	68.0
	3	104,025	87,028	83.5	420,000	288,743	68.8	69.7
*	5.75	126,000	92,387	73.2	181,000	103,696	57.5	53.6
	1.5	128,700	105,960	82.0	1,130,040	751,946	66.5	67.2
	1.66	200,640	191,197	95.2	1,365,811	1,276,458	93.3	90.7

quipped with plunger pumps.

nt for the 20-inch line, and 0.09 per cent for the 24 inch ie, out of a possible total time of 14,000 hours. The best idence of the lack of necessity for electric stand-by motors the fact that the Big Inch stations were not so equipped d they had a down time of only 14 hours in $1^{1}/_{2}$ years.

At the present time, the natural gas pumping through e long projected pipelines to the Eastern states is receiv- g considerable attention, since the electrification of the rmer Big Inch system in 1947. Centrifugal compressors e used in place of the conventional gas-engine-driven re- procating compressor, and since it is a new use for elec- c power, it was felt some mention should be made in this ticle of the possibilities or reason for the selection of elec- c motors in that case.

Conventional practices in the gas pumping industry fol- w the pattern of using compression ratios of 1.6 to 2.0 d station spacing of 80 to 100 miles which require about horsepower per million cubic feet per day. A station of is type will consume in a year an amount of gas about ual to one day's capacity of the line. Thus, if ten sta- ns are supplied, it may be said that the lost revenue sales gas in the East will amount to ten days' operating time.

In the case of the Big Inch system the ability to have out $4,000,000 of revenue gas at the end of a year, over e amount for sale had engines been installed, proved the rning point favoring electrification. Further develop- ents of using the gas turbine or steam turbine for gas mping are in the making, and some manufacturers pre- ct "that in five years all gas transportation in large- ameter lines will be accomplished with centrifugal com- essors." Electric power can prove its use, no doubt of onomic merit, in a great many instances.

OIL REFINING

REVIOUS STUDIES to determine the amount of electric power used in the oil refining process indicated a grad- l increase from year to year in kilowatt hours per barrel of crude changed. No definite information is available at this time concerning the electric power usage except that in 1939 the Census of Manufacturers data gave the electric power consumption (purchased and generated) as 2.24 kilowatt hours per barrel, and five years later a similar survey by Federal Power Commission in 1944 indicated comparable quantities of 3.18 kilowatt hours per barrel charged, which represented an increase of 8 per cent per year in use of electric power.

In 1944 the ratio of electric usage was 35 per cent generated and 65 per cent purchased, or a gain of 2 per cent per year for purchased power over comparable figures for the year 1939.

As of 1949, the average complete oil refinery would require essentially the following services:

Purchased kilowatt hours per barrel of crude oil input	2.8
Generated kilowatt hours per barrel of crude oil input	0.92
Installed horsepower of motors using purchased and generated electric power per barrel of hourly crude oil input	9.5
Pounds of 200-pound 50-degree superheated steam generated per barrel of crude oil input	200.0
Equivalent mechanical power per barrel of crude oil input, kilowatt hours	2.1
Barrels of water to be circulated per barrel of crude oil input	24.5
Make-up for cooling towers, boilers, and blowdown, car washing, and so forth, per cent	9.5
Cubic feet of 1,000-Btu gas or equivalent (petroleum coke, acid sludge, still gases)	510

REFERENCES

1. Annual Drilling Edition. *Oil and Gas Journal* (Tulsa, Okla.), 1950.
2. *Industrial Power*, Federal Power Commission, Washington, D. C., 1945.
3. *Bulletin 4944*, Interstate Commerce Commission, Washington, D. C., 1948.

Transformer Magnetizing Inrush Currents

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THERE ARE formulas available by which it is possible to calculate the peak of the first cycle of magnetizing inrush current for a transformer. There have been no convenient formulas available for determining the maximum values of successive cycles of current. The usual approach has been to use a step-by-step process of mechanical integration that is quite time-consuming and usually is not worth the effort. Below are presented approximate formulas for determining the maximum values of the successive cycles of current that will be satisfactory for the majority of cases where this information is desired.

Most of the usual formulas given for calculating the maximum of the first cycle of inrush current neglect the resistance of the winding of the transformer and the eddy currents flowing in the core of the transformer. For the usual transformer the winding resistance is kept small so that the efficiency of the transformer will be good and the temperature rise of the transformer will be reasonable. For most transformers, it is a good approximation to neglect the winding resistance when calculating the maximum current for the first cycle. The eddy currents flowing in the core are essentially in parallel with the path for magnetizing current for the core. If the resistance of the transformer winding is small, the voltage drop through this resistance due to the eddy currents in the core will be small. Therefore, the voltage applied to the magnetizing path is not materially changed by the eddy currents. Hence, the effect of the eddy currents on the inrush current is negligible.

The magnetizing inrush current for the first cycle is unidirectional. This direct component of current flowing through the resistance of the circuit produces a direct voltage that reduces the residual flux in the core for that cycle. The value of the residual flux for the start of the second cycle then can be used in the conventional formulas to give the maximum current for the second cycle. This process is continued to secure the complete magnetizing inrush curve.

The formula used for the saturated reactance of the transformer is as follows

$$X_t = \frac{20 f N^2 A_s 10^{-8}}{h} \text{ ohms}$$

where A_s is the area inside the mean turn of the coil excited in square inches, and h is the height of the coil excited in inches.

The maximum current for a particular cycle is where

$$i = \frac{1.15\sqrt{2}E}{X}(1-\cos\theta) \text{ amperes}$$

where E is the applied voltage, X is the sum of X_t, the transformer saturated reactance and the system reactance, and the angle θ is one-half of the angle of current flow fo a given cycle. The factor 1.15 is an experience facto that should be 1 theoretically.

The half-angle of current flow for the first cycle is

$$\theta_1 = 0.9\cos^{-1}\frac{B_s - B_m - B_R}{B_m}$$

where B_s is the saturation flux density for the core, B_m i the maximum steady-state flux density in the core due t the applied voltage E, and B_R is the residual flux densit in the core. These three should all be in the same units The 0.9 factor is an experience factor that should be 1 theoretically. The half-angle of any successive cycle o current flow is

$$\cos\theta = \cos\theta_1 + \frac{2.26R}{X}\sum_{1}^{n-1}\Delta(\theta)$$

where R is the sum of the transformer winding resistanc and the supply resistance. The factor 2.26 is an experienc factor that should be 1 theoretically. The number of th cycle is n. The quantity $\Delta(\theta)$ is

$$\Delta(\theta) = 2(\sin\theta - \theta\cos\theta)$$

The angle θ should be in radians for this formula. Th quantity $\Delta(\theta)$ is evaluated for all the cycles precedin the given cycle using the values of θ corresponding to th various cycles. The sum of these then is used to calculat θ for the desired cycle. A curve can be drawn for $\Delta(\theta)$ a a function of $\cos\theta$, and the preceding summation proces carried out in tabular form.

These formulas neglect the eddy current loss in the core The experience factors used with the formulas should hel to take it into account. It is possible to derive formula for the average current and rms current of the inrus current, and also to draw some curves for determinin these and the peak current of each cycle. This is outline in another article.[3]

These formulas will make it possible to calculate with reasonable degree of accuracy the magnetizing inrus current curve. This should have application for fuse an relay protection of transformers.

REFERENCES

1. Transformer Engineering (book), **L. F. Blume.** John Wiley and Sons, Inc., Ne York, N. Y., 1938, pages 23–26.

2. Electrical Transmission and Distribution Reference Book (book), **Westinghou Electric Corporation.** The Lakeside Press, Chicago, Ill., 1942, pages 413–16.

3. Transformer Magnetizing Inrush Currents, **T. R. Specht.** AIEE *Transaction* volume 70, 1951 (*Proceedings T1-53*).

Digest of paper **51-53**, "Transformer Magnetizing Inrush Currents," recommended the AIEE Committee on Transformers and approved by the AIEE Technical Progra Committee for presentation at the AIEE Winter General Meeting, New York, N. Y January 22–26, 1951. Scheduled for publication in AIEE *Transactions*, volume 7 1951.

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Confinement of Transformer Noise

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The noise caused by one unit-type substation in a residential neighborhood was studied by the Pacific Power and Light Company in Portland, Oreg. The 4-wall enclosure of pumice blocks filled with sand, which was finally built to muffle the noise, is described.

THE RAPID increase in population and load density necessitat- g the installation of larger nsformers, the scarcity of itable substation property, e noise consciousness of the neral public, and the prac- e of working the new oriented or cold-rolled core steel to nigh flux density, have recreated a major problem which ıst be considered and solved by all electric utilities operat- g in well-developed residential areas. Low-frequency nsformer "hum" is apparently a noise to which the aver- e resident has not been accustomed. It differs from the utine traffic disturbances contributing to the general din ich all modern city dwellers casually accept but which uld have driven our forefathers from the confines of the y. The awareness of the utilities to the problem of trans- mer noise is demonstrated by the numerous papers pre- ted at engineering and operating meetings and the ex- riments in wall and building construction.

This article concerns the noise problems encountered er the energization of a newly installed unit substation in a idential area. It describes the attempts made, under essure to relieve adjacent substations of severe overload- , to secure immediate temporary reduction of noise el by drapes and noise cancellation devices, to accumu- e sufficient data from other utilities and from technical pers to permit an engineering approach to the problem, d to make tests on various building materials locally avail- le for insurance of an adequate permanent reduction in ise level at reasonable cost. A 4-walled enclosure con- ing of sand-filled hollow pumice block with partial tile f was finally designed and built with satisfactory results. Conclusions and recommendations include (1) insistence manufacturers for more consideration in design of noise- e transformers, (2) procurement of sufficient substation perty, (3) comparison of costs between excessive pre- um for reduction of innate transformer noise level below tional Electrical Manufacturers Association (NEMA) ndards and sound insulating enclosures, (4) selection of terial for enclosures plus desirability for energization of nsformer before completion of sound attenuating device, d (5) improvement in appearance of the substation.

NSTALLATION OF SUBSTATION AND COMPLAINTS

THE FALL of 1949 Pacific Power and Light Company completed installation of a 15,000/25,000-kva 110/66-11- unit-type substation with four feeder positions in a resi- ntial district in the southeast section of Portland, Oreg. ctors entering into the selection of the site included (1) se proximity to the load center, (2) size of ground area, (3) availability of property, (4) zoning code restrictions, and (5) ease of entrance of transmission tap line and egress of distribution feeders.

A site measuring approximately 70 by 95 feet was the largest area which could be secured to satisfy requirements. This property was located on an arterial thoroughfare flanked by a medium-class residential district. Owing to the somewhat limited size of the property acquired and the advisability of leaving space for future duplexing of the station, the transformer section of the initial unit was placed at the east end of the property near an adjacent frame dwelling.

When the unit substation was energized for service, residents in the area adjoining the substation vigorously complained of disturbing noise. Reflections from buildings created a crazy-quilt pattern of noise intensity.

An investigation which included sound-level tests based upon NEMA standards was made. Briefly, these tests consisted of averaging the readings taken at a number of points around the transformer at specified heights and at a distance of one foot from the major sound-producing surfaces. Since the switchgear cubicles were in place, all NEMA recommendations for test could not be complied with fully. The performance standards prescribe that for a 15,000-kva 115-kv oil-immersed self-cooled (Class *OA*) transformer the average sound level shall not exceed 75 decibels without fans and 79 decibels with fans when energized at normal voltage and frequency with no load. Tests indicated average sound levels of 71 decibels and 73.5 decibels respectively on the *A* or 40-decibel frequency-weighted scale with a maximum of 81.5 decibels without fans. All readings subsequently used in this article are without operation of fans.

To further aggravate conditions, the daytime average ambient noise level was approximately 40 decibels, but because of almost continuous heavy daytime traffic on Division Street the intermittent sound level rose at times to 100 decibels. This condition made the transformer noise at night seem more intense. To maintain good public relations and avoid statute violations of a zoning ordinance, a means of reducing the noise level of the substation was imperative.

PRELIMINARY EXPERIMENTS

TO ATTACK the problem and provide temporary relief it was necessary to explore the proportion of earth-borne and air-borne noise and to determine if the predomi-

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Essentially full text of paper 50-225, "Transformer Noise and Its Confinement," recommended by the AIEE Committee on Transformers and approved by the AIEE Technical Program Committee for presentation at the AIEE Fall General Meeting, Oklahoma City, Okla., October 23–27, 1950. Published in AIEE *Transactions*, volume 69, part II, 1950, pages 1409–16.

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nating frequency was that of magnetostriction, 120 cycles per second. Physically very little vibration could be felt on the substation pad and none could be noticed in the surrounding earth.

By the use of available equipment, including contact and crystal microphones, Ballantine vacuum-tube voltmeter, and cathode-ray oscillograph, it appeared that the resonant frequency of the concrete pad was 600 cycles and that of the transformer shell was 720 cycles. The contact microphone was utilized to measure this vibration. The contribution through the surrounding earth apparently was negligible. With a crystal microphone accurate from 50 to 10,000 cycles per second it appeared that the major air-borne frequency was 240 cycles. Later information included in this report showed that the frequency varied with the test location.

A quantity of burlap was purchased and a double layer approximately 20 feet by 20 feet was suspended between the transformer and the nearest residence. Even with many folds in this form of drape and with the burlap later saturated with water, no improvement could be observed. A better understanding of the distinction between sound absorption and sound insulation would have eliminated this test.

Noise cancellation was attempted then as another temporary expedient. A high-fidelity crystal microphone was used in conjunction with a very linear audio amplifier to drive two 12-inch cone-type speakers 180 degrees out of phase with the noise source and pointed in the direction of the desired noise reduction. The speakers were positioned about the transformer without accomplishing any successful improvement. The sound wavelengths of the various frequency components later determined to be present ranged from approximately 10 inches to 9 feet.

Because the microphone could not be located at the same spot as the speakers on account of feedback and because of the multiplicity of sound-generating sources on the transformer, the cancellation of noise from one source was offset by the reinforcement of noise from another source. However, additional thought is being given to this idea for possible future installations requiring immediate temporary relief. Perhaps some solution may be found for effective unidirectional cancellation for local areas perpendicular to a major transformer surface.

COMPILATION OF AVAILABLE INFORMATION

An accumulation of data through correspondence, review of technical papers, and inspection of installations of other utilities confronted with similar problems resulted in a collection of information concerning intercepting walls on one or more sides of the transformers, resilient pads under transformer bases, inner liners in compartments, heavy plantings of shrubbery, enclosures, and complete masonry buildings. All emphasized the severity of the problem and the impossibility of an exact analysis with specific improvement per dollar expended. In addition to the uncertainties of proper evaluation of noise measurements, the equation of ear response versus human reaction was most disturbing.

The following excerpts adduced from a recent technical paper by C. E. Baugh[1] were extremely pertinent.

"1. Units of the same design show a wide variation—a high as 12.5 decibels . . . in sound level.

"2. Units with cold-rolled steel cores have an averag sound level about 7.5 decibels higher than that of earlie units built to the same specifications.

"3. The housing of unit substations is contrary to th philosophy under which this type of apparatus was de veloped."

The study of information led to the conviction that th only solution for a substation of such a high noise level wa the construction of a suitable wall or barrier around th unit that would effect the reduction of the noise level at th locations of the complainants without interference wit necessary ventilation and operation.

Some thought was given to the use of Sound Metal pane in place of a masonry enclosure. The panels, as manufac tured, were constructed of a heavy steel frame faced wit perforated metal, and where exposed to the weather, th outside sheet was of solid metal. Separators were place in between the steel sheets and a high-grade spun minera felt packed within. This resulted in a meritorious produc having high absorption coefficients at low as well as hig frequencies. The cost of a complete enclosure of the sub station with Sound Metal panels was estimated to be con siderably more than masonry construction. No data wer available on their efficiency as sound insulation.

It is important at this point to note that there are two di tinct problems encountered when dealing with sound These are sound absorption and sound insulation. Soun absorption deals with the dissipation of sound incident upo a surface. In other words, a material having a high ab sorption coefficient will permit minimum reflection and re duce reverberation. Sound insulation applies to the reduc tion of sound intensity level when transmitted through structural wall. It is the problem of sound insulation wit which one is confronted in attempting to reduce transforme noise by the erection of walled enclosures. Practically a acoustical information on hand dealt with sound absorptio

Lacking definite information on the sound-insulatin qualities of the various acoustical materials, a series of tes was conducted on those thought to be most suitable for ex terior application. Experiments were made on variou acoustical wood fiber, cork, Fiberglas, and asbestos board but it was soon evident that these lighter materials were n efficient sound insulators. The attenuation of noise pas ing through these substances was insignificant. No suitab practical method was evolved to check published data o the sound-absorption coefficients of these materials. Diffe ences in reflection (and absorption) between panels of fib board, pressed shavings, plywood, and polished marb could not be detected with existing equipment.

These tests and previously published information on th efficiency of sound-insulating walled enclosures indicate that materials having large masses were required for ef cient noise attenuation. This explains why tests by th company and other utilities using burlap or canvas walls sound insulators produced negligible improvement. Pa ticular attention was therefore given to the various types masonry blocks available in the area.

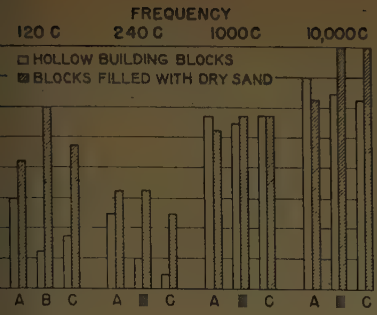

Figure 1. Sound attenuation tests through building blocks. (A) concrete, (B) pumice, (C) concrete-sawdust

he test procedure consisted of providing a directional e source, a wall of the material under test, and a sound- suring device. The noise source was provided by en- ing a speaker in a heavy plywood box open on one side lined on all inner surfaces with acoustical board. The ker was driven by an audio signal generator and a very ar audio amplifier which permitted control of both the nd intensity and frequency. The material under test ned the remaining wall. A General Radio sound-level er was used to measure the sound intensity before and r the wall was in place—the difference between the two lings was an indication of the sound-insulating efficiency ne wall material under test.

igure 1 illustrates the sound reduction obtained for fre- ncies from 120 cycles per second to 10,000 cycles per nd by the use of walls built of concrete, pumice, and con- e-sawdust blocks with and without sand filling. A very ceable increase in sound insulation at the lower fre- ncies was obtained in each case by filling the hollow cks with dry sand, an average of 12 decibels at 120 cycles second for the three types under discussion. Possibly ause pumice blocks were good sound absorbers as well as d sound insulators, the sand-filled pumice block con- ction appeared the best and was chosen for the con- ction of the substation enclosure. In contrast to these ings, one of the manufacturers repeatedly expressed an ion that even though the sand would add to the mass of walls it was doubtful if it would have any beneficial ct external to the enclosure. Although blocks were im- sed in water to measure its absorption, no tests were le to determine the characteristics of wet sand. How- , sound-dampening qualities of sand were believed better n dry and provision was made to keep the sand dry.

ollowing considerable study of sound-absorbent ma- ls, 2-inch-thick pressed Fiberglas panels of the type l for roof insulation were selected as an inner liner to pro- the most suitable means of additional sound absorp- if this was found necessary upon completion of the ding. By using pumice block construction these panels d be nailed directly to the inside of the wall.

DESIGN OF STRUCTURE TO CONFINE NOISE

ITH HOLLOW pumice blocks filled with sand showing superior qualities as a wall material, the task of de- ing an enclosure that would produce the expected re- at minimum cost and with an appearance that would n keeping with the buildings surrounding the substation tion was undertaken.

n addition to strenuous objections of adjacent residents, there were many complaints from customers at random locations about the substation. The noise pattern observed led to the conclusion that a 2-sided enclosure would probably cause sufficient reflections to create hot spots of even higher than original intensity on the unprotected sides. The exposure of the substation to the public in the adjacent main traffic artery was also a potent argument for an acceptable appearance. Although a complete roof did not seem practical because of the high-voltage leads, a partial roof seemed necessary to eliminate line-of-sight noise transmission and to reduce spill-over.

The enclosure finally adopted consisted of four closed walls 24 feet wide, 46 feet 8 inches long, and 16 feet 6 inches high built of pumice block masonry, using units 8 by 8 by 16 inches, erected on a reinforced concrete footing poured independent of all other station foundations, Figure 2. The height including partial roof was 21 feet 8 inches.

The cavities in the individual blocks were filled with sand after every six or eight courses of block were placed. Clean dry sand was used; it was well rodded to insure complete filling. The 4-inch-thick glass-block panels, which were added for decorative purposes only, measured 6 by 8 feet and were backed with pumice blocks which were 4 by 8 by 16 inches also sand-filled to provide full wall thickness at all points. Corner columns were built up of standard block units and concrete-filled to provide additional strength and to comply with the city building code.

Pumice sand was used in the mortar to provide a material having nearly the same expansion coefficient as the blocks themselves. Placed longitudinally in the mortar joint between every third course of blocks were steel reinforcing rods which served to reinforce the wall structurally and provide a method of stopping expansion cracks which might develop. The walls were capped with a partial roof consisting of a poured reinforced concrete slab covered with clay roofing tile, Figure 3.

The internal baffle wall mounted on an I beam shown in Figure 4 and extending from a height of approximately nine feet above ground to the top of the roof had a 3-fold purpose. First, it provided a wall close to the transformer for acoustical effect. Second, it furnished support in the long span of the roof slab. And third, it provided a division wall to help the chimney action in the enclosure by directing the warm air around the transformer directly upward.

Figure 2. Start of construction on pumice-block enclosure

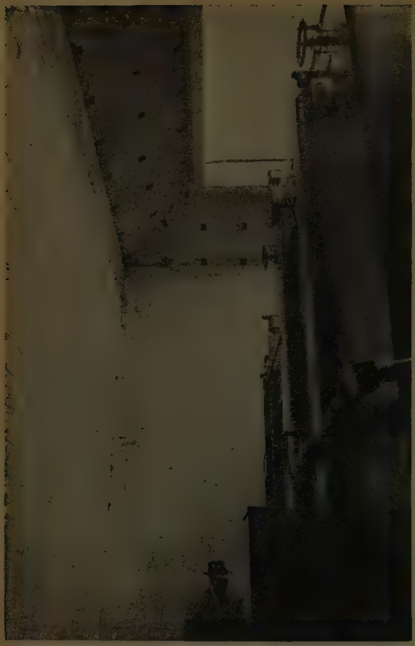

Figure 3. Interior of enclosure showing roof construction

Screened ventilation openings 16 by 16 inches were p
vided on three sides at the bottom of the walls. These w
originally shielded from direct noise transmission to
outside by a low baffle wall approximately 18 inches fr
the inside of the main wall and approximately 36 incl
high, Figure 5. In an effort to attenuate the noise furth
the openings were closed with 4-inch sand-filled pum
blocks on the interior side. The chimney action wh
was produced by the inner baffle wall provided adequ
ventilation.

Provision for internal lining of the enclosure roof with
Fiberglas insulation was made by placing wooden naili
blocks in the concrete as poured, Figure 3. Furring str
could be nailed directly to the pumice walls as supports
the insulating material. To date, noise reduction seems
be sufficiently effective to alleviate the necessity for this inn
lining.

In order that the transformer might be removed in eve
of an emergency, a panel of block was laid up in the fro
wall with vertical joints between pilasters. A concr
beam spanning between these pilasters supported the r
over this distance and sufficient vertical clearance was p
vided to permit removal of the transformer after removal
the bushings. Tap-changer compartment, feeder cubicl
and other portions too large for passage through the 4-
7-foot metal door could be removed by a crane through
opening in the roof.

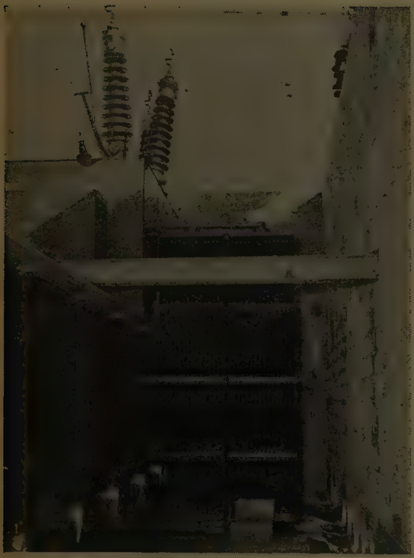

Figure 4. Interior of enclosure showing I-beam support for baffle wall

Consideration was given to the installation of a large se
ice door for removal of the transformer. One M
western utility company constructed such a door or pa
from 2-inch glass fiber bats completely enclosed in 20-gau
sheet steel. Although this panel proved to be almost
effective as a masonry wall, the cost of a similar panel
prohibitive when the anticipated infrequency of its use
considered. Estimates showed that the masonry secti
could be removed and replaced three times before the c
of the metal panel was exceeded.

Before, during, and after completion of the enclosu
tests of sound-level intensities were made at prearranged
cations or "stations" to determine, by comparison,
effect as various additions to the enclosure were complete
The completion of the entire enclosure was necessary bef
appreciable noise reduction was achieved. This reducti
of noise averaged about 23 decibels on the *B* or 70-deci
scale.

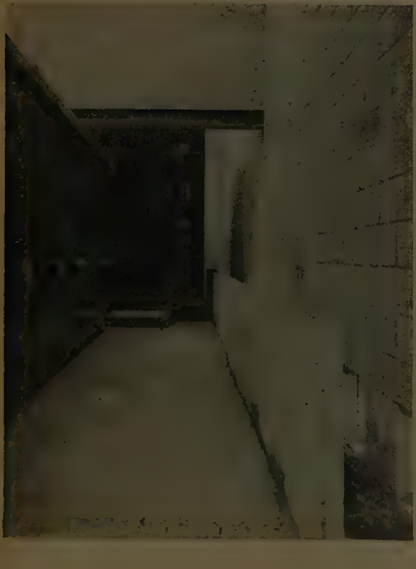

Figure 5. Interior of structure. Note small wall of uncemented pumice blocks originally installed to reduce sound transmission through ventilating openings

Attenuation at the property line on all four sides of
substation varied from 15 to 24 decibels with an average
18.5 decibels. As expected, the intensity level increa
inside the enclosure because of reflections. Figure 6 sho
the position of all test stations with the comparative readi
taken before and after the construction of the wall. Re
ings were taken throughout on all three scales of the sou
level meter, but because of the high intensity levels
countered the *B* or 70-decibel scale was used for the m
practical comparison. All readings were taken with
microphone about 12 inches above ground contour wh
varied approximately three feet. Initial and subsequ
checks indicated practically no difference in readings
yond a few feet from the transformer at different elevatio
Some of the erratic readings during construction are attri

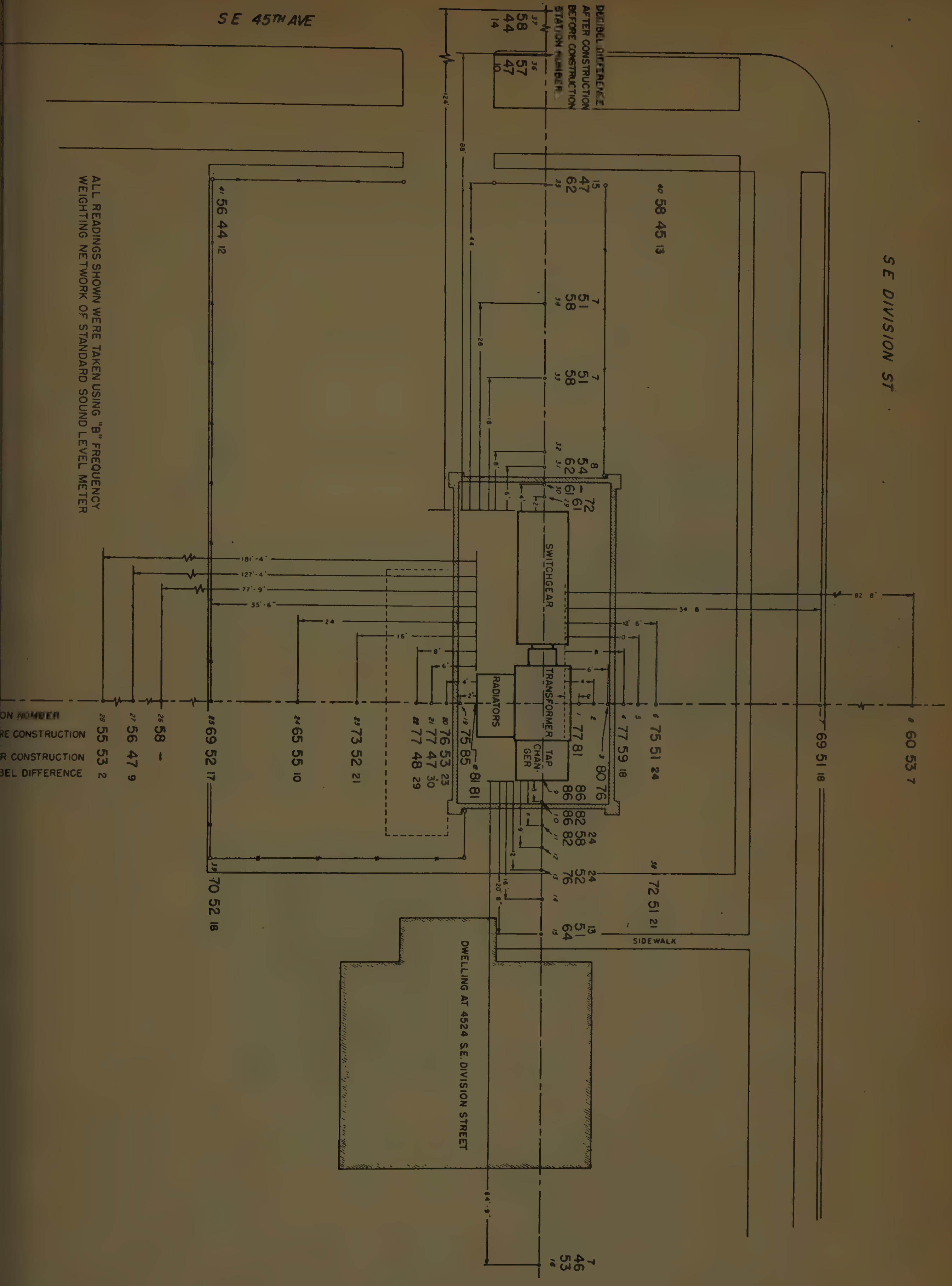

Figure 6. Comparative sound-level tests showing effectiveness of enclosure

Table I. Frequency Components of Transformer Noise

Before Closure of Ventilating Openings

Station	Decibel Sound Level, C Scale		Frequency, Cycles per Second										
			120	240	360	480	600	720	840	960	1,080	1,320	1,5
1*	81	Decibels	0	−16.0	−22.0	−30.0	−21.0					−22.0	
		Per cent	100	16	8	3	9					7	
1**	86	Decibels	−5.2	0	−6.0	−9.0	−13.0	−24.0	−20.0	−26.0	−27.0	−27.0	−3
		Per cent	55	100	50	35	23	6	10	5	4.5	4.5	
9**	88	Decibels	−2.0	−4.0	0	−12.5	−22.0	−26.0	−28.0	−28.0		−24.0	
		Per cent	80	62	100	19	8	5	4	4		6	
15*	74	Decibels	−3.0	−7.0	0	−12.0	−20.0		−25.0			−30.0	
		Per cent	70	45	100	25	10		6			3	
15**	62	Decibels	0	−14.0	−21.0								
		Per cent	100	16	9								
20**	74	Decibels	0	−1.0	−22.0	−15.5			−26.0		−30.0		
		Per cent	100	90	8	12			5		3		
29**	73	Decibels	0	−10.5	−12.0	−18.0		−20.0	−30.0	−30.0			
		Per cent	100	30	20	13		10	3	3			

* Readings before construction of enclosure.

** Readings after construction of enclosure but before bottom ventilating openings were closed.

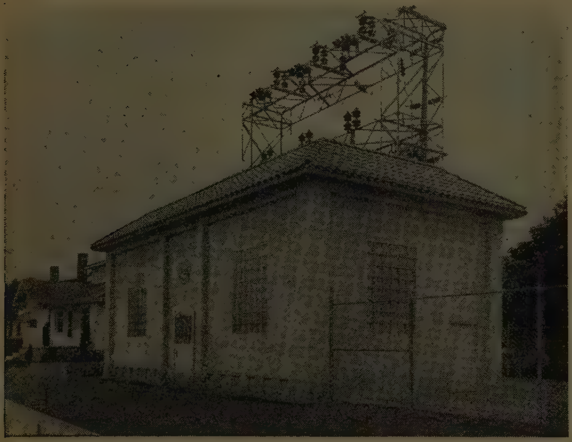

Figure 7. Substation transformer after completion of enclosure

table to the presence of piles of pumice blocks, sand, and other temporary foreign material.

NOISE FREQUENCY COMPONENTS

A General Radio Sound Analyzer Type *760A* was used in conjunction with the sound-level meter to secure the comparative values of frequency components before and after construction of the enclosure. From Table I it can be seen that the noise ranged from 120 to 1,560 cycles per second and that the predominate frequencies were either 120, 240, or 360 cycles per second depending upon test location and the progress of the enclosure construction. The transformer auxiliary equipment provided local sound sources of varying frequency and intensity.

It did not appear that effects of variation in ambient noise level were less for any specific frequencies. There seemed to be as much variation in the frequency analyzer readings at any given frequency due to ambients as there was for the total of all frequencies from the transformer.

The completed structure before planting of shrubbery is shown in Figure 7. A sprinkling system later was installed and lawn and shrubs planted.

During the assembly of materials and approximately two weeks before the start of the enclosure construction, the substation was energized and left in this condition until it was necessary to remove the voltage on the high-tension lea because of progress on the walls.

CONCLUSIONS

From experience gained in the attempt to reduce t transformer noise level, the following suggestions a offered when the installation must be in a residential are

1. Continue to press the manufacturers for more u form assembly with noise level an important feature in t design. The extreme variation in sound levels of identic unit substations included under the same purchase order a strong factor in this argument.
2. If possible, procure enough property so that the tra formers can be placed 100 feet from the nearest dwelli
3. Compare the additional cost of a more quiet tra former with the construction of a sound-confining enclosu There exists a 25-per cent increase in price for designi transformers at 10 decibels below NEMA levels. A decibel decrease in noise level might, therefore, increase t transformer cost by 50 per cent. Several enclosures cou be built for this high premium. The almost universal co sensus of those contacted appeared to be that this cost is u warranted and that the best procedure is to energize t substation and then apply remedial measures if require
4. If an enclosure is economically advisable, select its construction the available material that provides the b sound insulation and at the same time the greatest sou absorption. Energize the transformer two weeks befo construction and as much as possible during constructi to accustom the neighborhood to the noise and obtain psychological advantage as well as actual noise reductio
5. Improve the appearance of the substation and pro erty as much as economically justifiable.

REFERENCES

1. Audio Noise in Transformers in Residential and Commercial Areas, **C. E. Bau** AIEE *Transactions*, volume 69, part I, 1950, pages 121–8.

2. Quiet Transformer Installations—A Problem for Both Equipment and Substa Designers, **I. S. Mendenhall, F. L. Taylor.** AIEE *Transactions*, volume 69, par 1950, pages 1148–53.

3. Sound and the Human Ear, **S. Bennon.** *Westinghouse Engineer* (East Pittsbu Pa.), March 1949.

4. Theory and Use of Architectural Acoustical Materials. *Acoustical Materials Ass tion* (Chicago, Ill.).

A-C Arc Phenomena Near Refractory Surfaces

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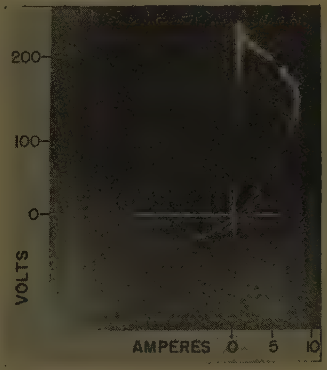
S FIRST STEPS in a general study of arc extinction or reignition in magnetic-type air circuit breakers, lographic techniques have been developed for simul- eously measuring both arc voltage and arc current ng the important few microseconds just before and current zero.

he volt-ampere cyclogram of Figure 1 is a record of measurements made at the extinction of a 280-ampere ycle arc in a 192-volt reactive circuit. This arc was wn between graphite electrodes spaced $1^1/_4$ inches apart pressed against a zircon porcelain surface. The arc held in contact with the surface by a transverse mag- c field. From such cyclograms time plots could be le of the important quantities, arc path conductance power input, as plotted in Figure 2 for the test of ure 1. The near-current-zero variation of apparent ductance characteristically showed an initial rapid ay followed by a much slower rate of change. It is eved that the slow change is due to cooling of the age path along the heated refractory surface following ual disappearance of the much more rapidly changing ductance of the gaseous arc path in parallel with it. actual arc conductance in this test appeared to fall exponentially with a time constant θ_a of 31 micro- nds. The ceramic leakage path behaved like a similar ductor with a time constant θ_s of 200 microseconds with its rate of decay considerably reduced by the r-critical power input which momentarily levelled off r 1,100 watts before dropping to zero at a later time.



ure 1. Volt-ampere cyclo- n of sample test on zircon elain at 280 amperes, 192 , $1^1/_4$-inch electrode spacing

n such "sample" tests at rather low current, extinction eignition of the arc clearly depended upon the sense of unbalance between two quantities: 1. the electric ver input to the refractory surface leakage path at the existing voltage gradient; and 2. the rate of energy loss from this surface, principally by heat flow into the plate material. Further sample tests were made in which the arc was confined between two parallel refractory plates, with one electrode touching one plate only and the opposite electrode touching only the other plate, thus simulating more closely the actual conditions existing in circuit-breaker arc chutes. The observed behavior of the arc path conductance in these tests was essentially similar to that in the single plate tests. This similarity is consistent with the fact that changes in the series-parallel arrangement of the conduction paths through the gas and the surface as current passes through zero are such that until the gas approaches complete deionization, considerable current can still be carried across the gap between the plates with low voltage drop. The time constant of conductance decay was observed in these tests to be affected markedly by plate spacing, with a maximum rate of decay at the smallest spacing.

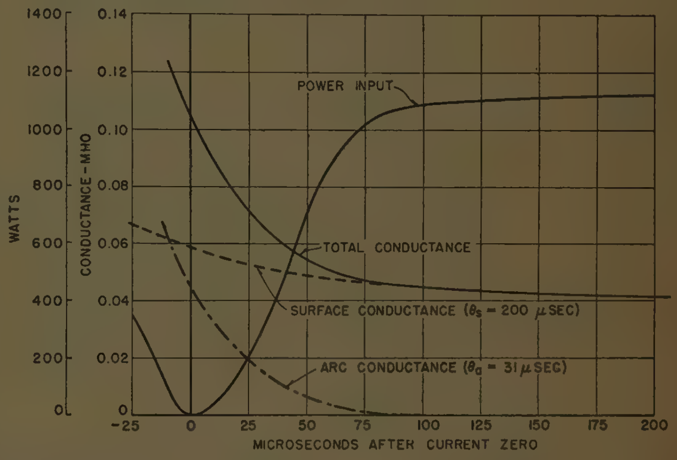


Figure 2. Analysis of apparent arc conductance near current zero for test of Figure 1

The results of a few studies by these methods of much higher current arcs in models of actual circuit-breaker chutes are still inconclusive, but it seems possible that decay of the gaseous arc path conductance may generally, or at least sometimes, be the factor limiting the current-interrupting ability of circuit breakers of this type.

Possible means revealed by the small sample studies for accelerating the decay of the gaseous arc conductance are: a gas flow through the arc resulting from decomposition of the adjacent surface material, and reduction in spacing between arc-confining surfaces. The possible impedance of strength of the magnet "blowout" field in magnetic circuit-breaker arc chutes is one of the remaining factors to be more fully investigated.

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t of paper **51-65**, "A Study of Conduction Phenomena Near Current Zero for An Arc Adjacent to Refractory Surfaces," recommended by the AIEE Committee on ctive Devices and approved by the AIEE Technical Program Committee for pres- on at the AIEE Winter General Meeting, January 22–26, 1951. Scheduled for cation in AIEE *Transactions*, volume 70, 1951.

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Generalized Electrical Formulas

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A set of generalized electrical formulas is developed to which units of any absolute system may be applied. The generalization is accomplished with the aid of two additional constants, *n* and *u*. The general formulas may be reduced to the usual rationalized or unrationalized forms or to the Gaussian or Heaviside forms by the substitution of tabulated numerical values of the constants *n* and *u* in the general form.

THE PROBLEM of units and unit systems has been of concern to electrical engineers since the beginning of quantitative work in the field of electricity. At present there are at least six unit systems in fairly common use. These systems are the Meter-Kilogram-Second (MKS) Unrationalized, the MKS Rationalized (A more exact name for this system would be "MKS Subrationalized" since it encompasses only a part of the Heaviside proposal. See discussion under the section on Definition of Unit Systems), the Centimeter-Gram-Second (CGS) Electromagnetic, the CGS Electrostatic, the Gaussian, and the Heaviside-Lorentz systems. The MKS Rationalized system seems now to be replacing the others rapidly and may well come to be the accepted system for all theoretical work in electricity. However, a clear understanding of the basis of most of the unit systems listed is essential to follow current literature effectively, and all are essential to the understanding of extensive reading in electricity.

The six systems listed are all absolute unit systems, and are defined in terms of five sets of fundamental units and four sets of electrical formulas. The five sets of fundamental units result in differences in magnitude among most of the derived units and thus require many multiplying factors for conversion from one system to another. However, the differences among the four sets of electrical formulas may result in even more confusion since it is often difficult to determine which system an author is using in a theoretical discussion unless one is thoroughly familiar with the four sets of electrical formulas. The name of the system being used is frequently not stated in the text.

This article presents a set of general electrical formulas which may be used as the defining equations for any of the six unit systems and thus, conversely, to which units of any of the six systems may be applied in making a numerical calculation. Of course, only one system may be used in a given calculation. The generality is accomplished by the addition of two arbitrary constants to the formulas, one to account for differences due to rationalization, and another to account for differences between the symmetrical and nonsymmetrical systems. V. Karapetoff[1] terms systems symmetrical in which both μ_v and ϵ_v are given the value 1 as in the Gaussian and Heaviside-Lorentz syste
It is not proposed that the general formulas be used
such for either theoretical developments or determini
quantitative results in a particular calculation. Rath
it is intended that they be used to determine the exact for
of a given relation for application to any one of the u
systems, or given a relation in unfamiliar form to determi
to which system it is applicable.

ABSOLUTE MEASURE

ALL ELECTRICAL unit systems are based on absolu
measure, that is, measurement based on the fund
mental units of length, mass, time, and one or more ar
trarily assigned electrical quantities. Any of the electric
quantities may be used, b
it is customary to use μ_v, t
permeability of free space,
the permittivity of free spac
or both. The use of μ_v or ϵ_v
the fourth quantity elimina
the necessity of producing
maintaining any fundament
physical standards other th
length and mass, the standa
of time being maintained
the rate of the earth's rot
tion. Units for all of t
other electrical quantities are determined in terms of th
defining equations[2] and by comparison with the thr
fundamental quantities: length, mass, and time. T
value of μ_v enters as a constant in the defining equatio
As an example, let the relation for the force between t
long straight parallel wires be the defining equation f
current. In the unrationalized form

$$F=\frac{2\mu_r\mu_v I_1 I_2 l}{r}$$

If F is expressed in dynes, $\mu_v=1$, and l and r in centimete
the relation defines the abampere. Practically, we co
calibrate an "abampere-meter" by adjusting the curr
until the force between the two wires spaced one centime
apart was equal to two dynes per centimeter length of li
For accuracy the experiment must be modified in for
but not in principle. Now, having calibrated a curr
indicating device, it is possible to measure charge in ter
of the relation

$$Q=It$$

Absolute units for the remaining electrical quantities
of course, determined in a similar manner. A set of el
trical units determined in this way may also be term
consistent as no arbitrary multiplying factors are requi

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n substituting magnitudes in terms of these units into electrical relations.

SOURCE OF RELATIONS

LL OF THE RELATIONS or formulas of a physical science are determined as the result of experiment, definition, vation, or generalization.[2,3]

xperimental relations are those which in a given nization of the science are considered to result directly n experiment. Relations which are termed experintal were usually so determined historically, but this s not imply that all relations which were originally ermined experimentally should be so termed. A good nization of a physical science utilizes experimental tions only when its development cannot be extended other means. For example, Joule's Law was originally ermined by experiment, but in the light of present wledge it may readily be derived.

efined relations are those which are true because of nition. An example is

$$F/Q$$

defining equation for the magnitude of electric field nsity.

erived relations are determined analytically, usually ugh the combining of experimental and defined relas.

eneralizations or postulates are relations which are med to be universally true because no exception to n has ever been observed.

he source of each relation in this organization of the eral basic relations of electricity is indicated in each It should be understood that other writers may to choose a different organization and thus to indicate fferent source for any given relation. It is only necesto be self-consistent in a given organization.

RATIONALIZATION

ET US CONSIDER the differences among the four sets of fundamental electrical relations which result from so-called process of rationalization. Since electrical nomena occur in space it is inherent that the factor hould appear in the consideration of cylindrical or rical surfaces or volumes. However, if the size of s is permitted to vary, the π's, or more frequently a or 4π, may be shifted about with considerable latitude ng the various relations. The process of rationalizaconsists of shifting the factor 4π into positions and tions which seem more logical than their position in classical relations.

s an example of rationalization let us consider Ampere's for the force between two long parallel currentying wires. This relation is taken frequently as the ning equation for the unit of current and in this organion is the starting point for deriving succeeding electrical tions.

he classical or unrationalized relation is

$$\frac{\mu_r\mu_v I_1 I_2 l}{r}$$

and the rationalized form is

$$F=\frac{\mu_r\mu_v I_1 I_2 l}{2\pi r}$$

It should be understood that the 2 and the 2π are purely arbitrary and are inserted only because previous experience teaches us that these constants will result in certain desirable features in the succeeding relations. The rationalized form evidently has no advantage in the equation. If the reader will study equations 9 and 15 through 22 in Appendix I with $u=1$ it will be evident that the choice of 2π in the denominator instead of 2 in the numerator in the expression for force between parallel wires results in the elimination of 4π from the magnetomotive force equation. Note that, in effect, a 4π was inserted in the denominator of the classical expression for force between parallel wires to accomplish rationalization, and that the elimination of 4π from the magnetomotive force relation followed without any additional arbitrary insertion of the 4π. Only one additional 4π need be inserted arbitrarily in the classical form of the relations to accomplish rationalization of the relations listed in this article. The additional 4π is inserted arbitrarily in the denominator of Coulomb's Law of force between point charges.

It should be understood that the two sets of electrical relations, rationalized and unrationalized, may be developed without any consideration of units. A unit system is defined by applying four or more fundamental units such as length, mass, time, and absolute permeability to the relations as defining equations. It is evident that a given set of fundamental units will result in different derived units with different defining equations.

THE CONSTANT *n*

IF A SINGLE SET of electrical relations is to encompass both the rationalized and unrationalized forms, an additional constant must be inserted in certain of the relations. This may be accomplished by inserting the constant n where necessary and replacing it by 4π to obtain the unrationalized set and by 1 to obtain the rationalized set. Following this procedure results in generalized relations of rationalized form. The generalized relations can also be developed in the unrationalized form by a different choice of values for the constant n.

THE GAUSSIAN RELATIONS

THE GAUSSIAN SYSTEM of units is a CGS system with μ_v and ϵ_v both set equal to 1, and an unrationalized form of relations used as the defining equations. As a result of this choice of basic quantities, units for magnetic field quantities correspond to those of the CGS electromagnetic system and units for electric field quantities correspond to the CGS electrostatic system.[4] The units of charge, current, voltage, resistance, capacitance, and inductance correspond with the electrostatic system also. Since the units of the electrostatic and electromagnetic systems differ in magnitude by a factor of c or c^2, where c is numerically equal to the velocity of light, the constant c or c^2 appears in the Gaussian relations which involve units from both systems. For example, the classical expression for the magnetic field intensity about a long straight wire is

$$H=\frac{2I}{r}$$

and the Gaussian expression is

$$H=\frac{2I}{cr}$$

The c must be inserted because in the Gaussian system current I is expressed in statamperes and field intensity H in gilberts per centimeter or oersteds. Thus the Gaussian relations correspond with the classical relations except for the inclusion of the factor c or c^2 in a number of the relations.

The Heaviside-Lorentz relations are formed by rationalizing the Gaussian relations. Thus they carry the factor c or c^2 in exactly the same positions as the Gaussian relations but the 4π's are shifted into the rationalized position.

THE CONSTANT *u*

A CONSTANT u is inserted in certain of the general relations to account for the differences among relations resulting from the introduction of the Gaussian and Heaviside-Lorentz systems. The constant u is set equal to c to form the relations for these two systems and equal to 1 for the other systems.

DEFINITION OF THE UNIT SYSTEMS

The CGS Electromagnetic System. The CGS Electromagnetic system is defined in terms of the centimeter, gram, second, and $\mu_v=1$, with the classical relations as the defining equations.

The CGS Electrostatic System. The CGS Electrostatic system is defined in terms of the centimeter, gram, second, and $\epsilon_v=1$, with the classical relations as the defining equations.

The MKS Unrationalized System. The MKS Unrationalized system is defined in terms of the meter, kilogram, second, and $\mu_v=10^{-7}$, with the classical relations as the defining equations.

The MKS Rationalized System. The MKS Rationaliz system is defined in terms of the meter, kilogram, secon and $\mu_v=4\pi\times10^{-7}$, with the rationalized relations as t defining equations. This system is sometimes called t subrationalized system since a truly rationalized syste similar to Heaviside's system would set $\mu_v=10^{-7}$. Ho ever, this would result in change in the practical units current and voltage by the factor $\sqrt{4\pi}$ and change in t units of resistance and inductance by the factor 4π. I one is seriously proposing such a change at present sir it would require recalibration of most of the elect instruments. Since the 4π's reappear when numeri values of μ_v and ϵ_v are used for computation, subrationaliz tion has its major advantage in theoretical work. H Heaviside's proposal been adopted, the 4π's would ha been shifted into the instrument calibrations and th largely eliminated from theoretical and practical work.

The Gaussian System. The Gaussian system is defin in terms of the centimeter, gram, second, $\mu_v=1$, and $\epsilon_v=$ with the Gaussian relations as defining equations.

The Heaviside-Lorentz System. The Heaviside-Lorer system is defined in terms of the centimeter, gram, secor $\mu_v=1$, and $\epsilon_v=1$, with the Rationalized Gaussian Heaviside-Lorentz relations as the defining equations.

TABLE OF FUNDAMENTAL UNITS

THE FUNDAMENTAL UNITS and the defining relations the six systems are summarized in Table I. Qua tities enclosed in brackets are experimentally determin constants in the particular system involved.

THE GENERAL FORMULAS

THE GENERAL FORMULAS are readily derived by writi the four forms of each and then inserting the constar n and u by inspection. As an example of the derivati let us consider the four forms of the relation for the for between two long straight parallel current-carrying wire

$$F=\frac{2\mu_r\mu_vI_1I_2l}{r}\quad\text{(Classical)}$$

Table I. Table of Fundamental Units

Unit System	Length	Mass	Time	μ_v	ϵ_v	Defining Relations
CGS Electromagnetic	centimeter	gram	second	1	[1.113×10^{-21}]	Classical (unrationaliz
CGS Electrostatic	centimeter	gram	second	[1.113×10^{-21}]	1	Classical (unrationaliz
MKS Unrationalized	meter	kilogram	second	10^{-7}	[1.113×10^{-10}]	Classical (unrationaliz
MKS Rationalized (Subrationalized)	meter	kilogram	second	$4\pi10^{-7}$	[8.854×10^{-12}]	Rationalized
Gaussian	centimeter	gram	second	1	1	Gaussian
Heaviside-Lorentz	centimeter	gram	second	1	1	Heaviside-Lorentz (Rationalized Gaussi

Table II. Table of Fundamental Units for General Formulas

Unit System	Length	Mass	Time	μ_v	ϵ_v	n	u	Relati
CGS Electromagnetic	centimeter	gram	second	1	[1.113×10^{-21}]	4π	1	Gener
CGS Electrostatic	centimeter	gram	second	[1.113×10^{-21}]	1	4π	1	Gene
MKS Unrationalized	meter	kilogram	second	10^{-7}	[1.113×10^{-10}]	4π	1	Gene
MKS Rationalized (Subrationalized)	meter	kilogram	second	$4\pi10^{-7}$	[8.854×10^{-12}]	1	1	Gene
Gaussian	centimeter	gram	second	1	1	4π	c*	Gene
Heaviside-Lorentz	centimeter	gram	second	1	1	1	c*	Gene

* c is numerically equal to velocity of light (2.998×10^{10} centimeters per second).

$\frac{\mu_v I_1 I_2 l}{2\pi r}$ (Rationalized)

$\frac{\mu_r \mu_v I_1 I_2 l}{c^2 r}$ (Gaussian)

$\frac{\mu_v I_1 I_2 l}{2\pi c^2 r}$ (Heaviside-Lorentz)

onsider first the rationalized form. Inserting 4π in numerator reduces it to the unrationalized form. Thus ould be inserted in the numerator of the rationalized 1. With $n=1$ the general form reduces to the raalized form and with $n=4\pi$ to the unrationalized form. t insert the factor u^2 in the denominator of the raalized form. With $u=1$ the general form reduces to classical or unrationalized forms, and with $u=c$ to Gaussian or Heaviside forms. Thus the general nula is

$$\frac{\mu_r \mu_v I_1 I_2 l}{2\pi u^2 d}$$

of the general formulas may be derived in a similar nner.

UNDAMENTAL UNITS FOR GENERAL FORMULAS

HE FUNDAMENTAL UNITS which must be applied to the general formulas to define the six unit systems are d in Table II. The table also serves as a guide in ucing the general relations to any of the four forms of ial relations. For example, any of the general relations reduced to Gaussian form by setting $n=4\pi$ and $u=c$.

THE GENERAL FORMULAS

HE GENERAL FORMULAS are listed in Appendix I in the logical order of their development. The authors er starting their development of electrical relations force between parallel wires rather than Coulomb's of force between charges in order to conform with the rnational adoption of μ_v as the fourth fundamental ntity of the MKS systems. Thus the first electrical nula presented defines the electrical quantities involved out borrowing ideas from subsequent parts of the nization. The source of each relation, that is, whether erimental, defined, derived, or generalization, is inated.

Appendix I. General Equations

Length: l

Mass: m

Time: t

Velocity (defined): $v=l/t$

Acceleration (defined): $a=v/t$

Newton's law of force (experimental): $F=ma$

Work (defined): $W=\int F\cos(F, dl)dl$

Power (defined): $P=W/t$

Law of force between long parallel wires (experimental): $\frac{\mu_v \mu_r I_1 I_2 l}{2\pi u^2 r}$

10. Relation between electric current and charge (experimental): $Q=It$

11. Potential difference or voltage (defined): $V=W/Q$

12. Ohm's law (defined): $V=IR$

13. Power in an electric circuit (derived): $P=I^2R=V^2/R=VI$

14. Energy in an electric circuit (derived): $W=I^2Rt=V^2t/R=VIt$

15. Force on a conductor perpendicular to a magnetic field (defined): $F=BIl/u$

16. Magnetic flux (defined): $\phi=\int B\cos(B, n)dA$

17. Flux density about a long straight wire (derived): $B=n\mu_r\mu_v I/2\pi ur$

18. Relation between flux density and field intensity (defined): $B=\mu_r\mu_v H$

19. Magnetic field intensity about a long straight wire (derived): $H=nI/2\pi ur$

20. Magnetomotive force (defined): $M=\int H\cos(H, dl)dl$

21. Magnetomotive force around a current (derived): $M=nI/u$

22. Magnetomotive force of a coil (derived): $M=nNI/u$

23. Field intensity of a current element (generalization): $dH=\frac{nI\sin(S, dl)dl}{4\pi uS^2}$

24. Field intensity about a wire of finite length (derived): $H=\frac{nI(\sin\alpha_1+\sin\alpha_2)}{4\pi ur}$

25. Field intensity on the axis of a concentrated circular coil (derived): $H=\frac{nr^2NI}{2u(r^2+x^2)^{3/2}}$

where r is the radius of the coil and x is the distance from the plane of the coil.

26. Approximate value of flux in a toroid (derived): $\phi=\frac{nNI\mu_r\mu_v A}{ul}$

27. Reluctance (defined): $R=M/\phi$

28. Reluctance of a rectilinear circuit (derived): $R=l/\mu_r\mu_v A$

29. Generated voltage (derived): $E=Blv\sin(B,v)/u$

The fact that a voltage is generated in a conductor moving perpendicular to a field must be observed experimentally. However, given this information, the magnitude of the voltage may be determined on the basis of conservation of energy and equations 7, 8, 13, and 15.

30. Flux linkages (defined): $\Lambda=N\phi$

31. Induced voltage (experimental): $e=\frac{N}{u}\frac{d\phi}{dt}$

32. Inductance (defined): $L=\frac{e}{d_i/dt}$

33. Inductance in terms of flux linkage (derived): $L=\frac{N}{u}\frac{d\phi}{di}$

34. Approximate inductance of a toroid (derived): $L=\frac{n\mu_r\mu_v N^2 A}{u^2 l}$

35. Low-frequency inductance of a long 2-wire line (derived): $L=\frac{n\mu_v l}{4\pi u^2}\left(4\ln\frac{D}{r}+\mu_r\right)$

36. Mutual inductance (defined): $M=\frac{e_2}{di/dt}$

37. Energy stored in inductive circuits (derived): $W=\frac{LI^2}{2}=\frac{N\phi I}{2u}$

38. Energy density in magnetic fields (derived):

$$\frac{W}{v}=\frac{\mu_r\mu_v H^2}{2n}=\frac{BH}{2n}=\frac{B^2}{2n\mu_r\mu_v}$$

39. Pull of an electromagnet (derived): $F=B^2A/2n\mu_v$

40. Coulomb's Law of force between point charges (experimental): $F=nQ_1Q_2/4\pi\epsilon_r\epsilon_v r^2$

41. Electric field intensity (defined): $\mathcal{E}=F/Q$

42. Voltage as line integral of field intensity (derived): $E=-\int \mathcal{E}\cos(\mathcal{E},dl)dl$

43. Field intensity about a point charge (derived): $\mathcal{E}=nQ/4\pi\epsilon_r\epsilon_v r^2$

44. Displacement density (defined): $D=\epsilon_r\epsilon_v\mathcal{E}$

45. Displacement (defined): $\psi=\int D\cos(D,n)dA$

46. Displacement from a point charge (derived): $\psi=nQ$

47. Capacitance (defined): $C=Q/V$

48. Capacitance of parallel plates (derived): $C=\epsilon_r\epsilon_v A/nd$

49. Capacitance of concentric cylinders (derived): $C=\dfrac{2\pi\epsilon_r\epsilon_v l}{n\ln(r_2/r_1)}$

50. Energy stored in a capacitor (derived): $W=CV^2/2$

51. Energy density in electric fields (derived):

$$\frac{W}{v}=\frac{\epsilon_r\epsilon_v\mathcal{E}^2}{2n}=\frac{\mathcal{E}D}{2n}=\frac{D^2}{2n\epsilon_r\epsilon_v}$$

52. Force between large charged parallel plates (derived): $F=n\sigma^2A/\epsilon_r\epsilon_v$

53. Maxwell's equations (derived):

$$\text{Curl }\mathbf{H}=\nabla\times\mathbf{H}=\frac{\epsilon_r\epsilon_v}{u}\frac{\partial\mathcal{E}}{\partial t}+\frac{\mathbf{n}}{\mathbf{u}}\;\mathcal{E}\sigma+\rho v$$

$$\text{Curl }\mathcal{E}=\nabla\times\mathcal{E}=-\frac{\mu_r\mu_v}{u}\frac{\partial\mathbf{H}}{\partial t}$$

$$\text{div }\mathbf{B}=\nabla\cdot\mathbf{B}=0$$

$$\text{div }\mathbf{D}=\nabla\cdot\mathbf{D}=n\rho$$

54. Wave equations for free space (derived):

$$\nabla^2\mathcal{E}=\frac{\epsilon_v\mu_v}{u^2}\frac{\partial^2\mathcal{E}}{\partial t^2}$$

$$\nabla^2\mathbf{H}=\frac{\epsilon_v\mu_v}{u^2}\frac{\partial^2\mathbf{H}}{\partial t^2}$$

55. Intrinsic impedance of free space (derived): $\eta_v=\dfrac{n}{u}\sqrt{\dfrac{\mu_v}{\epsilon_v}}$

56. Phase constant of free space (derived): $\beta=\dfrac{2\pi f}{u}\sqrt{\mu_v\epsilon_v}$

57. Velocity of propagation of an electromagnetic wave in free space (derived): $v=\dfrac{u}{\sqrt{\mu_v\epsilon_v}}$

58. Poynting vector (defined): $P=\dfrac{u}{n}\mathcal{E}\times H$

Appendix II. Examples

EXAMPLES 1 and 2 illustrate the application of the general formulas to numerical examples.

Example 1. Calculate the magnetic flux density at a point 2 meters from the center of a long straight wire carrying 100 amperes.

$B=n\mu_r\mu_v I/2\pi ur$

(A). CGS Electromagnetic system

$I=10$ abamperes; $n=4\pi$; $u=1$; $\mu_v=1$; $\mu_r=1$; $r=200$

$B=4\pi\times1\times1\times10/2\pi\times1\times200=0.10$ gauss

(B). CGS Electrostatic system

$I=30\times10^{10}$ statamperes; $n=4\pi$; $u=1$; $\mu_v=1.113\times10^{-21}$; $\mu_r=$ $r=200$

$B=4\pi\times1\times1.113\times10^{-21}\times30\times10^{10}/2\pi\times1\times200=3.34\times10^{-12}$

There is no name for the unit of magnetic flux density in the C Electrostatic system. The numerical result is in agreement with t value in (A) since there are 3×10^{10} electromagnetic units of magne flux density in one electrostatic unit.

(C). Gaussian system

$I=30\times10^{10}$ statamperes; $n=4\pi$; $u=3\times10^{10}$; $\mu_v=1$; $\mu_r=1$; $r=20$

$B=4\pi\times1\times1\times30\times10^{10}/2\pi\times3\times10^{10}\times200=0.10$ gauss

(D). MKS rationalized (subrationalized)

$I=100$ amperes; $n=1$; $u=1$; $\mu_v=4\pi10^{-7}$; $\mu_r=1$; $r=2$

$B=1\times1\times4\pi10^{-7}\times100/2\pi\times1\times2=0.10\times10^{-4}$ webers per squa meter

(E). Heaviside system

$I=\sqrt{4\pi}\,30\times10^{10}$ units; $n=1$; $u=3\times10^{10}$; $\mu_v=1$; $\mu_r=1$; $r=20$

$B=1\times1\times1\times\sqrt{4\pi}\,30\times10^{10}/2\pi\times3\times10^{10}\times200=0.10/\sqrt{4\pi}$

Example 2. Calculate the intrinsic impedance of free space.

$$\eta_v=\frac{n}{u}\sqrt{\frac{\mu_v}{\epsilon_v}}$$

(A). MKS unrationalized system

$n=4\pi$; $u=1$; $\mu_v=10^{-7}$; $\epsilon_v=1.113\times10^{-10}$

$$\eta_v=\frac{4\pi}{1}\sqrt{\frac{10^{-7}}{1.113\times10^{-10}}}=377\text{ ohms}$$

(B). MKS rationalized

$n=1$; $u=1$; $\mu_v=4\pi\times10^{-7}$; $\epsilon_v=8.854\times10^{-12}$

$$\eta_v=\frac{1}{1}\sqrt{\frac{4\pi\times10^{-7}}{8.854\times10^{-12}}}=377\text{ ohms}$$

Example 3. Reduce the general equation for the intrinsic impedan of free space to the Gaussian form.

$$\eta_v=\frac{n}{u}\sqrt{\frac{\mu_v}{\epsilon_v}}$$

$n=4\pi$; $u=c$

From which

$$\eta_v=\frac{4\pi}{c}\sqrt{\frac{\mu_v}{\epsilon_v}}$$

References

1. A General Theory of Systems of Electric and Magnetic Units, **V. Karapet** AIEE *Transactions*, volume 51, 1932, pages 715–27.

2. Introductory Electrodynamics for Engineers (book), **Edward Bennett, H. Crothers.** McGraw-Hill Book Company, New York, N. Y., 1926, page 631.

3. Teaching Electricity and Magnetism, **V. P. Hessler.** AIEE *Transactions*, volu 65, 1946, pages 828–33.

4. The Formation of Systems of Units, **W. M. Hall.** *Journal*, Franklin Instit (Philadelphia, Pa.), volume 225, 1938, pages 197–218.

5. Fundamentals of Electrical Engineering (book), **V. P. Hessler, J. J. Carey.** M Graw-Hill Book Company, New York, N. Y., 1948.

6. The Fourteen Systems of Units (book), **W. R. Varner.** O. S. C. Cooperat Association, Corvallis, Oreg., 1948.

Single-Step Voltage Regulator Application

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HE DESIGN LIMITS of rural distribution circuits
usually are determined by permissible voltage drop
ner than the thermal limitations of the conductor. Pres-
ly overloaded circuits supplying power at inadequate
age levels are the result of conservative estimates of
d growth. Overloaded circuits highlight the need for
xpensive voltage correction equipment.

he application of single-step regulators cascaded on
al distribution circuits to correct excessive voltage drop
new. It presents a different concept, as the regulators
not subject to control within a narrow bandwidth,
merely by minimum and maximum voltage limits.
cessive voltage drop is the voltage drop which is over
determined limits. Single-step voltage regulators are
able of economically correcting excessive voltage drop.

Experimental single-step regulators have been tested on
lines of the Oakdale Cooperative Electrical Association,
kdale, Wis. Figure 1 shows a simplified diagram of a
gle-step regulator. A voltage-sensitive control is used
actuate a mechanism which in turn switches a series
nding for a boost or neutral connection.

Distribution line voltage limits are established on the
owing basis: voltage limits of 116 to 127 volts at the
sumers' distribution transformers; voltage limits of
) to 127 volts at the consumers' meters; and voltage
its of 107 to 127 volts at the points of utilization. The
ply voltage to the distribution circuit is regulated to
d the full-load voltage between 124 and 127 volts and
light-load voltage between 120 and 124 volts. This
its the voltage drop along the distribution lines to a
ximum of eight volts. All voltage values given are
erred to a 120-volt base.

Two single-step regulators cascaded on a line is the
ximum practical number that will operate satisfactorily
hin these limits. The voltage boost per regulator is
ited to 4.5 volts.

Voltage profiles for a 30-mile single-phase distribution
are shown in Figure 2. Curve 1 represents the existing
d, curve 2 the estimated future peak load, and curve 3
estimated future light load. Curves 2 and 3 are ob-
ned by extrapolation of curve 1. Two single-step
ulators are used to correct the estimated future nine
ts' excessive drop. The location of these regulators
determined from curve 2. Curve 4 represents the esti-
ted future drop at full load with correction and shows the
ation of the regulators.

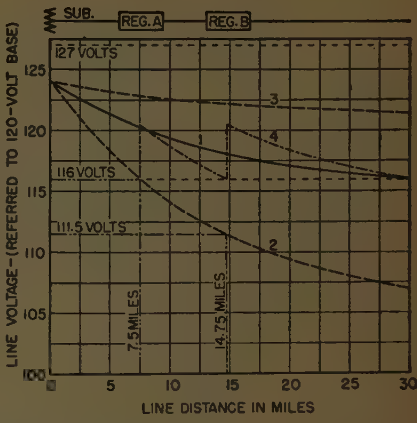


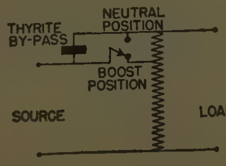
Figure 2. Voltage profiles of an assumed distribution line. (1) Present full-load; (2) estimated future full-load; (3) estimated future light-load; (4) estimated future full-load with correction

Single-step regulators raise the voltage before any point along the line drops below the minimum limit and lower the voltage before any point along the line rises above the maximum limit. This is done by adjusting the regulator control for a boost operation when the voltage at the load side of the regulator is 120 volts or lower, and for a neutral operation when the voltage at the load side of the regulator is 127 volts or higher. In order that normal line voltage variations will not cause excessive operations of the regulator, there is, following each operation, a leeway of 2.5 volts between the output of the regulator and the actuating voltage setting of the control. During a normal loading cycle, regulator *A* may raise the voltage and cause regulator *B* to lower the voltage. This is not serious as the voltage boost is merely changed from location *B* to location *A*. Regulator *B* will again raise the voltage before the voltage at the end of the line drops below 116 volts.

One regulator is capable of correcting 4.5 volts' excessive voltage drop. Therefore, a second regulator need not be installed until the excessive drop is greater than 4.5 volts. If both regulators are in the boost position and the line voltage continues to drop until the total line drop exceeds 17 volts, additional correction is needed. Since the capability of the two single-step regulators has been reached, other means of correction are needed.

A single-step regulator should be inexpensive, have a simple control with fixed settings, be easily installed, and require little maintenance. However, the installed cost of two units should be competitive with the cost of one multistep regulator having equal capability.

Additional operating experience will introduce factors which may affect the desirability of using single-step voltage regulators. However, present experimental installations indicate that this method of voltage correction has definite possibilities on long rural distribution lines.



ure 1. Simplified diagram of single-step regulator

Digest of paper 51-39, "Single-Step Voltage Regulator Application," recommended by the AIEE Committee on Transformers and approved by the AIEE Technical Program Committee for presentation at the AIEE Winter General Meeting, New York, N. Y., January 22–26, 1951. Not scheduled for publication in AIEE *Transactions*.

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A Nation-Wide Frequency-Modulated Telegraph Network

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The object of this article is to report on the success achieved in operating the only large frequency-modulated telegraph network. Years of experience with thousands of frequency-modulated telegraph channels have demonstrated that they may be operated in long tandem chains with excellent continuity of service.

THE THEORETICAL and technical aspects of recent advances in the carrier current telegraph art are well covered by the technical literature of record communication.[1–5] For the most part, the comparisons recorded have been the result of laboratory work or short-term service trials. Now the operating results achieved on a narrow-band frequency-modulated network can be reported as based on years of experience with nearly 2,000,000 miles of such circuits.

FIRST LARGE-SCALE APPLICATION

IN 1946, Western Union undertook a modernization and mechanization program which resulted in a tremendous expansion of its existing carrier network. This involved a conversion of multiplex circuits previously employed for trunk-line service to single-printer operation and a replacement of the d-c physical circuits with carrier channels. The program covered practically all long-haul facilities and a large part of the shorter feeder circuits. A full appreciation of the conditions under which these circuits operate and the high performance standards demanded will be enhanced by an understanding of the rou ing and automatic switchi methods by which separa telegraph circuits are inte connected in the modern tel graph plant. Manual rela ing, the process of reprodu ing the telegraph message paper and retransmitting by a telegraph operator, h practically disappeared. A few relatively large reperf rator switching offices have been established in heavi loaded traffic centers. Each such office serves a select territory or area; all messages to and from that area a routed through the switching center and automatically semiautomatically retransmitted to the offices of destinatio A description of the reperforator switching system whi obviates manual handling and which now serves the enti nation is recorded in a paper by R. F. Blanchard and W. Blanton.[7] Fifteen switching centers are interconnected by multiplicity of frequency-modulated carrier telegraph cha nels as they are also connected to a great many smaller ce ters within each area. Only the very short circuit conne tions and those serving smaller towns remain on physical d telegraph wires.

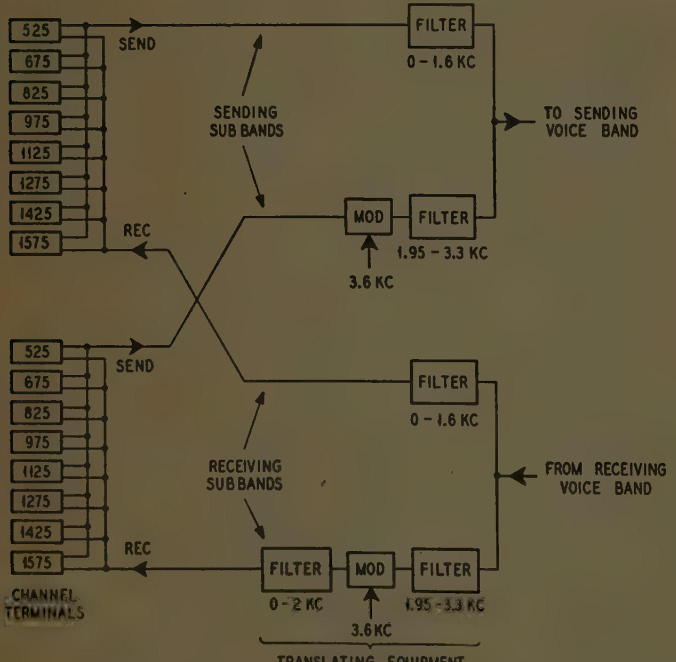

Figure 1. Block diagram of subband grouping

EQUIPMENT

PRESENT-DAY VF bands, either those derived from th Western Union Telegraph Company carrier systems f wire line and radio relay systems or those leased from th American Telephone and Telegraph Company and th associated companies, have a bandwidth of approximate 3,000 cycles. It has been found expedient to subdivide suc bands into two subbands, and to operate eight or nine tel graph channels in each subband. To provide maximu flexibility with minimum variety in the types of equipme required, the carrier equipment is built up of standard uni arranged to meet various conditions. The telegraph cha nel terminals are normally assembled in groups of eigh completely wired on a 10-foot rack. These terminal se are wholly electronic; the outgoing carrier is frequenc modulated by the telegraph printer or other transmitti machine, and the incoming carrier is detected and amplifi to a power level sufficient to drive the reperforator or print on the receiving side. Designed specifically for singl channel teleprinter service, they are capable of meeting t

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Full text of paper 51-62, "A Nation-Wide Frequency-Modulated Telegraph Netwo recommended by the AIEE Committee on Telegraph Systems and approved by AIEE Technical Program Committee for presentation at the AIEE Winter Gen Meeting, New York, N. Y., January 22–26, 1951. Scheduled for publication in A *Transactions*, volume 70, 1951.

F. B. Bramhall and L. A. Smith are with the Western Union Telegraph Comp New York, N. Y.

most commonly required d-c leg conditions, full du- half duplex, and carrier terminals tandem connected to back. The eight channels normally comprising one of terminals have mid-frequencies spaced 150 cycles with the lowest channel centered at 525 cycles and the st at 1,575 cycles.

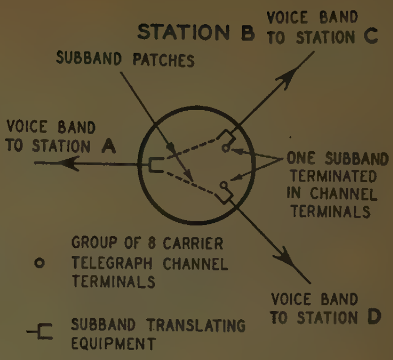
e regulating equipment, such as rheostats for building eg resistance, bias adjusting potentiometers, common quipment, and so forth, is divorced from the channel nal bays and concentrated at a central location in the ting room. Several different arrangements are used ssembling the standard control , each arrangement being de- d for a given class of office.

ure 1 shows schematically the nd separation and modulation ment employed with this od of working. The method has istinct advantages. First, manu- ing and warehousing econo- are effected because the num- f different types of oscillators, , and discriminators required y half that needed under the pattern where all frequencies ed to fill the voice band were ly generated, selected, and detected. Second, the r group of channels is found a more convenient unit he standpoint of traffic routing and dispatching, since e part of the total network is comprised of feeder cir- to smaller communities which can be served by the group of channels. This advantage results in the ex- n of subbands from one system to another by means band patches as illustrated in Figure 2. Patches be- complete bands, without separation into subbands, re employed.

ce bands over which the channels are operated are d from a number of sources as dictated by circum- s. Still, to the telegraph channels all voice bands ap- s two unidirectional paths (4-wire circuits) whether timate transmission medium be a 2-wire or a 4-wire equency carrier or a radio relay system. Commonly ransmission mediums are Western Union's own 2- nd 4-wire carrier systems, which range in capacity ne subband in either direction using a top frequency c to the 150-kc radio relay system which handles 64 d groups.[8] In leased American Telephone and aph Company facilities, channel groups, usually not an two subbands, operate on *C*, *J*, *K*, and *L* s.[9–12]

full capacity of the voice band is not realized, of when its load is only two groups of eight channels On many circuits where the traffic demands, a total hannels are operated in the voice band by the expedi- assigning the frequency spectrum as depicted in the f Figure 3. Two additional channels are secured by the 375-cycle *J* channel to each group. If need be, h and 20th channels, the *K* and *L*, are added, com- filling the space left as a guard band between the d filters. These channel allocations are 1,725 and 1,875 cycles respectively, maintaining the 150-cycle separation pattern.

Figure 2. Typical subband interconnections


STATION B
VOICE BAND TO STATION C
SUBBAND PATCHES
VOICE BAND TO STATION A
ONE SUBBAND TERMINATED IN CHANNEL TERMINALS
GROUP OF 8 CARRIER TELEGRAPH CHANNEL TERMINALS
SUBBAND TRANSLATING EQUIPMENT
VOICE BAND TO STATION D

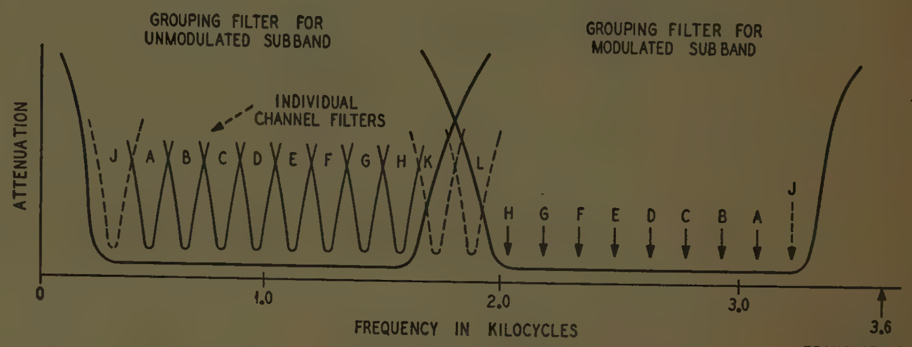


Figure 3. Twenty channels may be operated in the voice band by assigning the frequency spectrum in this manner

CIRCUIT LAYOUTS

Figure 4 is a circuit map of the trunk carrier telegraph channels now operated between the reperforator switching centers. This circuit map does not show trunk connections to New York, Chicago, or Washington, three major traffic centers which originate a substantial proportion of the nation's telegraph traffic. Figure 5, a map of New York trunk carrier circuits, is typical of the three major offices which are not actually switching centers but which involve large networks of carrier trunk circuits.

Circuits are considered as direct carrier trunks if they are derived from two or more carrier bands with a patch between subbands or bands, the criterion being a continuous carrier frequency connection without intermediate conversion down to d-c signals. Where eight or nine channels suffice for trunk service between two traffic centers, a voice band between these centers is not utilized completely. The remaining capacity, therefore, is employed for establishing trunk service to some other distant center by a subband patch.

Referring to Figure 4, it will be seen that direct carrier trunks as defined here are not always provided between a given switching center and all other switching centers. Where a group of direct carrier trunks is not justifiable, carrier transmission is obtained by a d-c telegraph patch between two trunk carrier circuits. As an example, a Boston-Minneapolis connection is easily established by a d-c leg connection between a Boston-Cincinnati channel and a Cincinnati-Minneapolis channel.

The use of carrier circuits for all trunk services has proved an economical application of modern techniques. Still, in

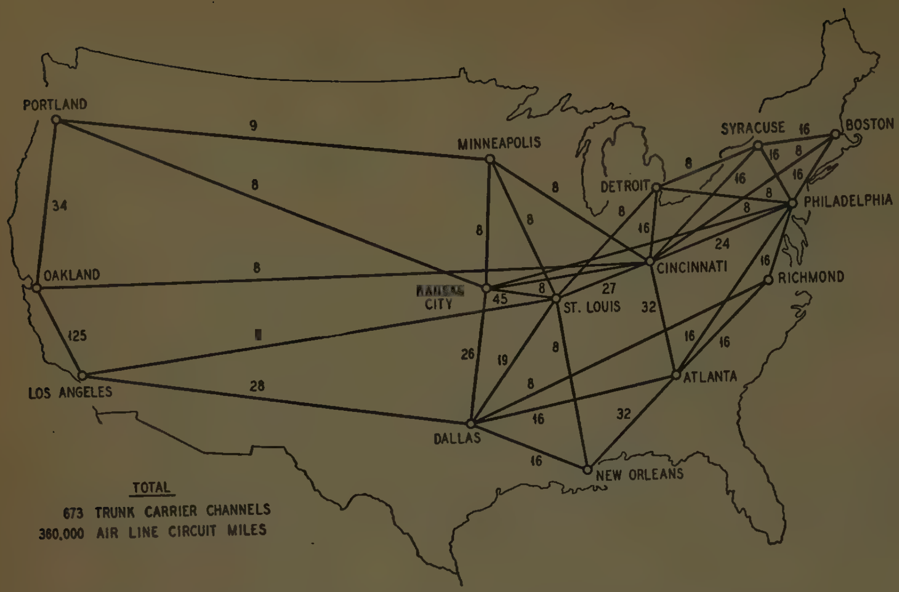


Figure 4. Direct carrier telegraph channels between switching centers

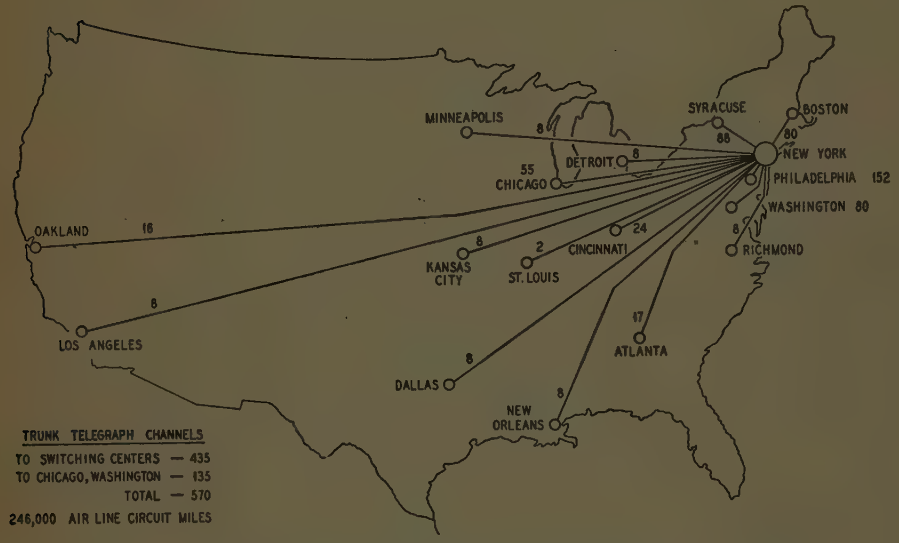


Figure 5. Direct carrier telegraph channels serving New York City

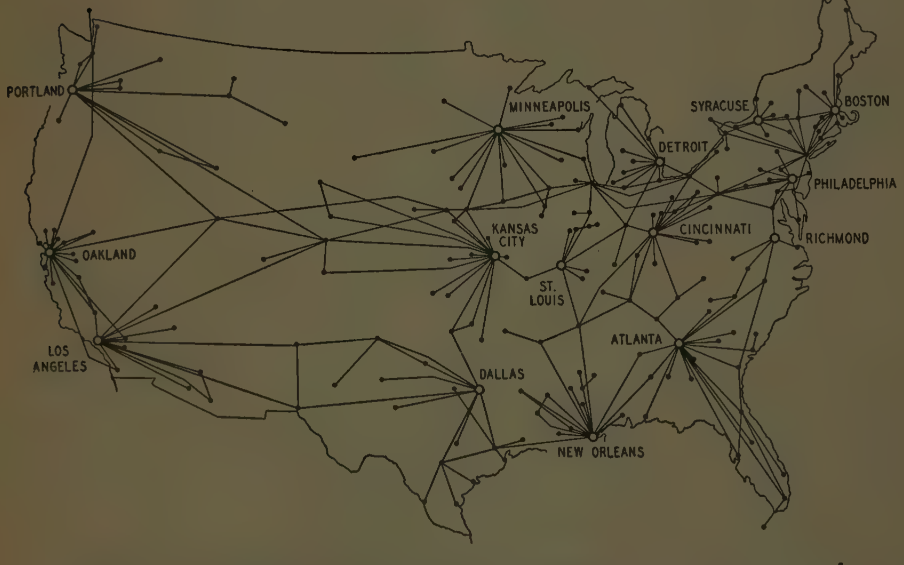


Figure 6. Tributary circuits spread out radially from switching centers

large measure the success of Wester
Union's switching system and carrie
network can be credited to the so
called tributary carrier circuits whic
connect various points in each are
to the switching centers. The ter
"tributary circuit" as used here al
includes circuits operating to certa
important telegraph offices, such
Buffalo, Cleveland, Denver, Pitt
burgh, and so forth, since busine
from these points is routed via t
automatic reperforating equipme
at the established centers. Trib
tary circuits spread out radially fro
the switching centers as illustrat
by Figure 6.

The average switching center
equipped with 400 channel term
nals, one-third of which operate
trunk-line service and two-thirds
scattered locations in the are
Figure 7 shows the assignments
the 318 channel terminals located
Minneapolis, a typical example.
this total, 103 are assigned to tru
service and the remaining 215 cha
nels provide carrier service to
towns and cities in the area. Th
tributary carrier circuits bring
the major cities, and the small tow
as well, within direct reach of the
perforator switching mechanis
Many of them are extended via
telegraph facilities as illustrated
Figure 8. Here a small town *A* op
ates via a relatively short d-c te
graph line into a carrier channel t
minal in the tributary office *B*, a
thence via a carrier channel dir
to the switching center at office
Business originating at *A* is manua
transmitted on a teleprinter circ
but there is no handling of any k
at *B*, and at *C* the circuit termin
directly in the switching equipm
which automatically handles the
quired retransmission.

All manner of direct telegraph c
nections, or the equivalent of di
connections without manual hand
at intermediate points, are est
lished by this arrangement. Ne
6,000 channels are now in operat
totaling almost 2,000,000 cir
miles. Of this number, about 1,
are employed for direct trunk c
nections, and around 4,000 for tr
tary circuits. The switching fa
ties provided at reperforator cen

ait almost instantaneous connections between any two ts in the network, regardless of the size of the offices lved or their locations.

OPERATING PERFORMANCE

OM THE VIEWPOINT of the traffic engineer, operating erformance is measured in terms of teleprinter range continuity of service provided. Distortion losses due lters and electronic equipment are extremely small. en a teleprinter circuit is operated through one carrier on, the range obtained is practically a short-circuit e. Where two or more carrier sections are operated in lem (with or without intervening relays at repeaters rted for obtaining drops), the operating range decreases tly with each added section. Figure 9 shows this ct. It is quite inevitable that any data such as recorded his graph are gathered under more or less controlled ditions. Still every effort was made, by continued repe- n of measurements and by performing the tests on more one set of tandem-connected channels, to get the best ible indication of the performance to be expected in fic service. Whenever more than n or eight tandem sections are lved in a given circuit, inter- liate regenerative repeaters are vided to reduce the net effect insure a minimum teleprinter ge of at least 65 points.

ince any interruption requires sferring traffic to parallel facili- or rerouting via other cities to ntain a telegraph connection, imum lost time on each circuit is ortant. The improvement in inuity of service obtained from use of the carrier network can be trated by examining the results lost-time study made on a trans- inental circuit. One of the few aining multiplex circuits was for this time study because it nitted a direct comparison of the e traffic circuit under an all- nded condition (13 repeater sec- s) and an all-carrier condition arrier sections with d-c leg patch between). Results of study are given in Table I. The all-grounded circuit loyed two regenerative repeaters.

he tremendous decrease in lost time with carrier oper- n is attributable to several major factors:

Lost time due to circuit failures decreases for two ons. Present-day carrier circuits operate on all-cable d facilities in many cases, and since cable circuits are subject to failure than open-wire lines formerly em- ed, the number of interruptions is decreased. When nterruption occurs, the time required for circuit restora- is comparable for grounded and carrier circuits but a it line-up is not ordinarily necessary for carrier, whereas 10 minutes usually were consumed by circuit realign- t after a wire failure on a long-distance grounded circuit.

Table I. Lost-Time Analysis

Second New York, N. Y.–Oakland, Calif. 2-Channel Multiplex 24-Hour-a-Day Operation

May 1946 All-Grounded Circuit 13 Repeater Sections			August 1950 All-Carrier Circuit 2 Carrier Sections		
Trouble	Number of Delays	Delay in Minutes	Trouble	Number of Delays	Delay in Minutes
Wire trouble			Carrier circuit failure	12	151
New York-Chicago	4	162	Loss of synchronism	25	25
Chicago-Denver	8	311	Fails and clears	4	9
Denver-Oakland	12	233	Total	41	185**
Circuit line-up					
Daily over-all	27	810			
Partial	40	1,021			
Other trouble					
Fails and clears	13	111			
Earth currents	6	135			
Equipment	5	63			
Loss of synchronism	71	84			
Miscellaneous	4	50			
Total	190	2,980*			

* 49 hours 40 minutes.

** 3 hours 5 minutes.

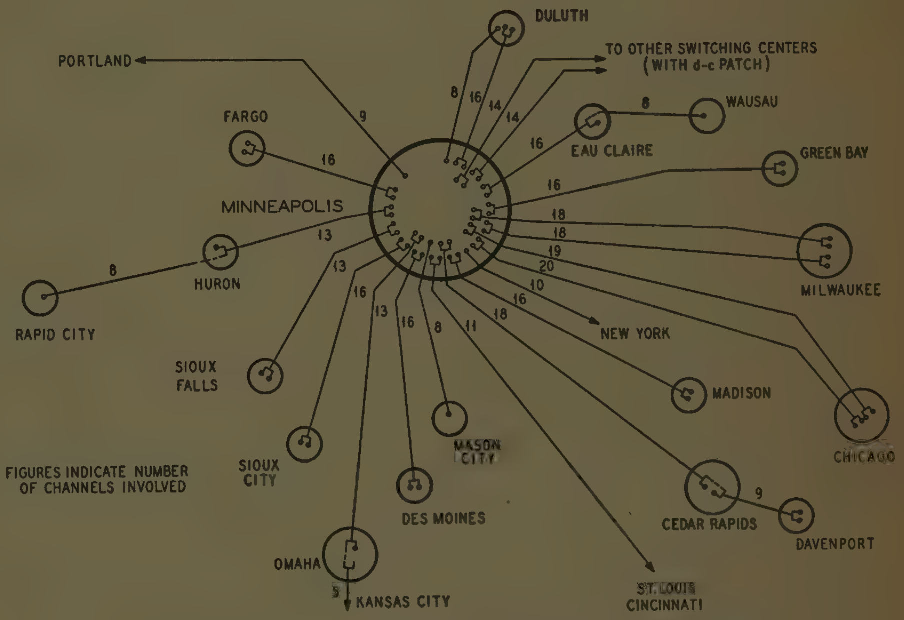


Figure 7. Carrier channel assignment of typical area center

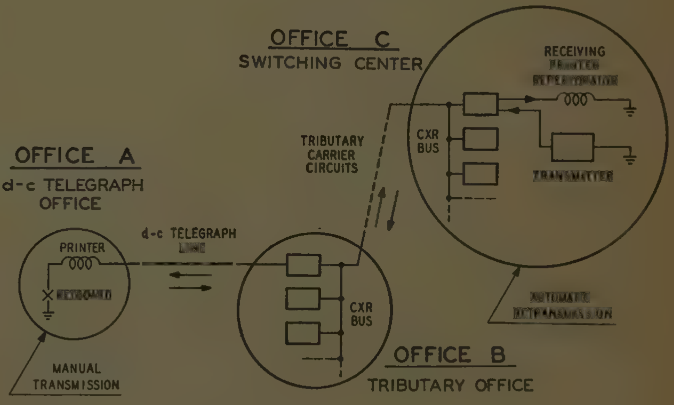


Figure 8. Typical tributary circuit arrangement

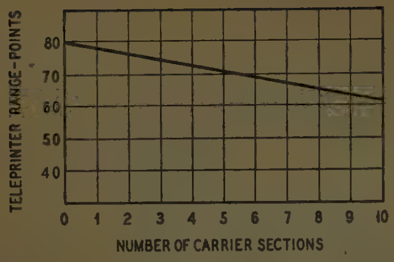


Figure 9. **Effect of tandem sections on teleprinter range**

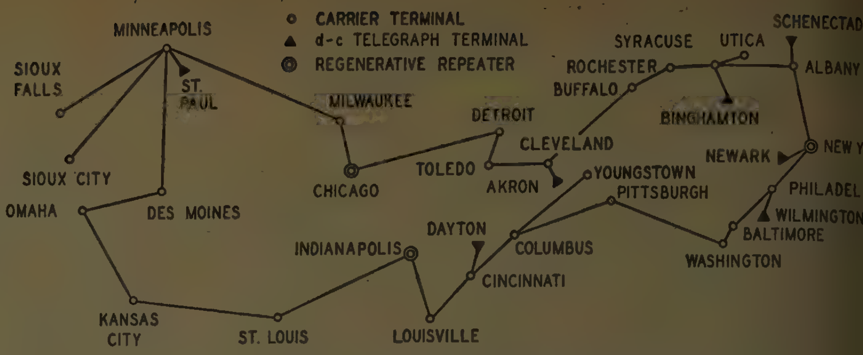


Figure 10. **3,300-mile circuit involving many carrier sections**

2. Routine or emergency circuit line-ups which required considerable time on the long grounded circuits are practically eliminated with carrier operation. The line-ups on grounded circuits were necessitated primarily by balance changes due to variable weather conditions.

3. Certain types of trouble, such as earth currents, affect grounded circuits but have little effect on carrier circuits.

4. Failures which clear without locating the exact cause are more prevalent on grounded circuits.

A similar improvement in the operation of long-distance teleprinter circuits has been experienced, but comparative data cannot be presented because all long-distance circuits in the Western Union network were operated multiplex before the advent of carrier. However, studies of existing long-distance teleprinter circuits substantiate the excellent continuity of service obtained from carrier operation. The total lost time for a 1-month period for a few random circuits is given in Table II.

Shorter circuits show considerably less lost time, many operating without interruptions of any kind for an entire month or longer.

One further example of operating performance, which clearly illustrates the reliability obtained, is the round-robin circuit of Figure 10. This circuit consists of a continuous loop with 23 individual carrier sections totaling approximately 3,300 miles connected in tandem. Two independent message circuits, one operating clockwise and one counterclockwise, are established by this arrangement, with transmission originating at any one of 31 customers' stations scattered around the loop. Transmission from any given point is received at all other points. In spite of its complexity, the total lost time for all points in the circuit averages only 0.6 per cent.

Limited field installations during the 1930–1940 trial period convinced Western Union that frequency-modulation operation was more desirable than amplitude modulation for a carrier telegraph plant and also that carrier operation would be more advantageous than d-c physical operation. The results of a moderate increase in the carrier

Table II. **Total Lost Time**

Circuit	Number of Carrier Sections	Total Lost Time
New York-San Francisco	2	36 minutes
New York-Los Angeles	2	53 minutes
New York-Denver	2	1 hour 46 minutes
New York-Houston	3	1 hour 22 minutes
New York-San Antonio	5	1 hour 40 minutes

facilities a decade ago, followed by wholesale conversion
the past few years, have confirmed this conclusion.
stallation, operation, and maintenance have been econo
cal, and the continuity of service obtained has improved t
a marked degree.

REFERENCES

1. Advances in Carrier Telegraph Transmission, **A. L. Matte.** *Bell System Tech*
Journal (New York, N. Y.), volume 19, 1940, page 161.

2. High-Speed Voice-Frequency Carrier Telegraph System, **F. B. Bramhall.** A
Transactions, volume 59, 1940, pages 873–8.

3. A Frequency Modulation Telegraph Terminal Without Relays, **F. H. Cusack**
E. Michon. AIEE *Transactions*, volume 66, 1947, pages 1165–71.

4. Frequency-Modulated Carrier Telegraph System, **F. B. Bramhall, J. E. Bos**
wood. AIEE *Transactions*, volume 61, 1942, pages 36–9.

5. Performance Characteristics of Various Carrier Telegraph Methods, **T. A. Jo**
K. W. Pfleger. *Bell System Technical Journal* (New York, N. Y.), volume 25, 1946.

6. Frequency Shift Telegraphy—Radio and Wire Applications, **J. R. Davey,**
Matte. AIEE *Transactions*, volume 66, 1947, pages 479–93.

7. Push Button Switching in Telegraph Systems, **R. F. Blanchard, W. B. Blan**
AIEE *Transactions*, volume 67, part II, 1948, pages 1733–40.

8. A 150-Kc Carrier System for Radio Relay Application, **J. E. Boughtwood.**
Transactions, volume 67, part I, 1948, pages 577–82.

9. A New Three-Channel Carrier Telephone System, **J. T. O'Leary, E. C. Bles**
J. W. Beyer. *Bell System Technical Journal* (New York, N. Y.), volume 18, 1939.

10. A 12-Channel Carrier Telephone System for Open-Wire Lines, **B. W. Ken**
H. A. Affel. *Electrical Engineering* (AIEE *Transactions*), volume 58, July 1939,
351–60.

11. An Improved Cable Carrier System, **H. S. Black, F. A. Brooks, A. J. Weir,**
Wilson. AIEE *Transactions*, volume 66, 1947, pages 741–6.

12. Frequency Division Techniques for a Coaxial Cable Network, **R. E. Cram**
T. Dixon, G. H. Huber. AIEE *Transactions*, volume 66, 1947, pages 1451–9.

Puerto Rican Paper Adopts Radi

The first newspa
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newsroom

Servomechanisms with Linearly Varying Elements

M. J. KIRBY
MEMBER AIEE

ORE AND MORE situations arise in which the variation of the elements of a servomechanism with must be considered in analyzing the system. A od is presented for determining the stability of a servo-anism in which one or more elements vary linearly time, that is, when the system can be described by a ential equation of the form

$$_nt)\frac{d^n\theta_0}{dt^n}+\ldots+(a_j+b_jt)\frac{d^j\theta_0}{dt^j}+\ldots+(a_0+b_0t)\theta_0=F(t) \qquad (1)$$

e θ_0 is the output, and $F(t)$ is the input, its derivatives, roducts of these by time t.

uation 1 is linear; its solution can be separated into a cular integral which is a function of $F(t)$ and is usually dered the steady-state solution, and a complimentary ion referred to henceforth as the transient response. latter is the solution to equation 1 with the right side l to zero.

system will be defined to be stable if the transient re-e, when excited, dies out completely as time ap-ches infinity. If any part of the transient response sts or increases indefinitely, the system will be consid-unstable.

e method of determining stability is based on the fact the transient response can be expressed as a definite ral[1] in the plane of an arbitrary complex variable s. not necessary to write this integral in order to apply the ion. As $t \rightarrow \infty$, the integral approaches the sum of n s of exponential type

$$\frac{\epsilon^{\gamma_1 t}}{{}^{+\lambda_1}}+\frac{k_2\epsilon^{\gamma_2 t}}{t^{1+\lambda_2}}+\ldots+\frac{k_n\epsilon^{\gamma_n t}}{t^{1+\lambda_n}} \qquad (2)$$

γ's are the roots of the polynomial $P(s)$ formed from the cients of the variable terms in equation 1

$$b_ns^n+b_{n-1}s^{n-1}+\ldots+b_1s+b_0 \qquad (3)$$

γ_j will in general be complex, with a real part α_j and nary part ω_j. When the α's are not zero, the expo-al factor dominates each term and determines the ual rise or decay of that part of the transient response. e problem of determining stability therefore is reduced ermining the signs of the real parts of the roots of the omial $P(s)$.

ere are three possible cases:

If all the γ's lie in the left half of the s plane, the sys-
s stable.

If any γ lies in the right half of the s plane, the system
table.

If the real part α of any γ is zero, the stability of the system must be determined from the $t^{-\lambda-1}$ factor for that term. If the real part of $(-\lambda-1)$ is negative, the term decays and does not cause instability. If the real part of $(-\lambda-1)$ is positive for any term for which α is zero, the system is unstable.

Each λ_j corresponding to a term $\epsilon^{\gamma_j t}/t^{\lambda_j+1}$ is the corresponding coefficient in the partial fractions expansion of $Q(s)/P(s)$

$$\lambda_j=\left.\frac{Q(s)}{\frac{dP(s)}{ds}}\right|_{s=\gamma_j} \qquad (4)$$

where

$$Q(s)=a_ns^n+a_{n-1}s^{n-1}+\ldots+a_js^j+\ldots+a_1s+a_0-[nb_ns^{n-1}+ (n-1)b_{n-1}s^{n-2}+\ldots+2b_2s+b_1] \qquad (5)$$

If $P(s)$ is not too complicated, the signs of the real parts of the γ's can be found by inspection of $P(s)$, or by application of simple rules. If this is not practical, a criterion such as that of Routh-Hurwitz can be used, or a polar plot of $P(s)$ similar to a Nyquist plot can be used.

The method involves two restrictions. The coefficients of the differential equation 1 are limited to the first power of t. In addition, the coefficient of the highest derivative term must vary, that is, b_n must exist; the remaining a_j and b_j coefficients may be either finite or zero.

When an α_j is zero, the response of the servomechanism has no counterpart in the performance of a constant-coefficient system. The transient is oscillatory with frequency ω_j, but it increases or decays as $1/t^{\lambda_j+1}$ which will frequently be a fractional power of t, and is much slower than an exponential. Bessel functions of order zero are functions of this type.

Considerable information about the form which the transient approaches is given by the location of the γ's in the s plane, and by a polar plot of $P(s)$. Each ω represents a frequency of oscillation; each α is a damping constant. The farther each γ is from the real axis, the higher is the frequency of oscillation; the closer to the imaginary axis, the longer the tail, the slower the decay. The closeness with which the plot of $P(s)$ approaches the origin indicates the closeness of the γ's to the imaginary axis in the s plane. The frequency ω at which the polar plot most closely approaches the origin is the predominant frequency in the oscillation.

However, $P(s)$ is not a transfer function but rather has the properties of a characteristic equation. A plot of $P(s)$ can indicate the frequency and relative damping of the terms in the transient response, but cannot indicate the magnitudes of the terms, hence, cannot indicate overshoot.

REFERENCE

1. Ordinary Differential Equations (book), E. T. Ince. Dover Publications, New York, N. Y., 1944, chapter 18.

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f paper 50-274, "Stability of Servomechanisms with Linearly Varying Ele- recommended by the AIEE Committee on Feedback Control Systems and d by the AIEE Technical Program Committee for presentation at the AIEE neral Meeting, Oklahoma City, Okla., October 23–27, 1950. Published in *ransactions*, volume 69, part II, 1950, pages 1662–8.

irby is with Sperry Gyroscope Company, Great Neck, Long Island, N. Y.

Interexchange Tandem Trunking in the Los Angeles Metropolitan Area

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Twenty-four years have elapsed since the first large-scale machine switching tandem system was designed and installed for service in Los Angeles. As an intermediate switching center, the tandem office enabled operators to use the dial method of operation for establishing interexchange telephone connections over the associated trunking network. During the intervening years, it has facilitated the rapid handling of telephone calls between the various communities in and around the city.

THE PROVISION of telephone service between the communities of a large metropolitan area presents many problems. Appropriate quantities of switching equipment and cable pairs must be provided to carry the expected loads and to perform the functions required for interconnecting telephone users. The resulting plant design must be such that satisfactory service can be provided at a minimum cost to the subscriber. To meet these objectives, operating methods are required which will facilitate the rapid handling of high volume calling; economical plant design requires efficient operation and an economic balance between the cost of arrangements employed to improve plant efficiency and the value of the savings obtained. Since forecasts of the volume and distribution of future traffic are the bases for plant design, unpredictable variations in traffic growth and changes in telephone practice are some of the elements of risk associated with planning for growth.

Tandem operation provides one of the principal devices available for improving operating methods and plant efficiency. As an auxiliary switching center it is the hub of trunk plant in a large highly developed switching network interconnecting central offices and operating centers. In this capacity it is sensitive to all the unpredictable and changeable elements of advance telephone planning.

A recent contribution toward the solution of interoffice trunking problems has been the introduction of the crossbar tandem system. In Los Angeles, where large scale dial tandem trunking is employed only for interexchange traffic, the volume of calls has grown beyond the capacity of the original tandem unit and a multiunit tandem system is now in operation.

GENERAL BACKGROUND

THE SERVING AREA of the Los Angeles tandem network now comprises the Los Angeles metropolitan area proper plus additional points described later. The term "Los Angeles Metropolitan Area" has been employed include Los Angeles and surrounding communities, shown in Figure 1. The Los Angeles exchange, which the central core of the area, serves over 800,000 stations 14 district areas. The development of these district ar varies from 26,000 to more than 132,000 stations. Th of the district areas are subdivided, and each empl two central offices that geographically separat Other district areas are serv entirely from a single cent office. The surrounding changes each contain from c to five central offices. Wit the 35 telephone exchan which are involved, th are four manual-type cent offices and 75 dial offices t serve approximately 1,60 000 telephones in eight center areas. This equ ment may be said to be in primary serving area of the tandem system.

As in most metropolitan areas, the growth and complex of the telephone system in the Los Angeles area has lowed the industrial and residential development of communities which comprise it. In the early period, prior to 1919, interexchange telephone switching almost exclusively on a manual basis, and calls betw exchanges were handled as toll calls through man toll switchboards interconnected by suitable toll or tr circuits. With the increase in the volume of calls, howe the earlier methods of handling became cumbersome costly. A significant milestone in the succession of st taken to solve the problem was the establishment Los Angeles of the first large-scale dial tandem in 19 Since that time additional steps have been taken to k pace with the growing problem, and the result is the c plex network of circuits and switching arrangements is in use today.

While not of particular significance as an elem affecting the problem at hand, it is of interest to note the telephone service in the area is provided, each ir own territory comprising a part of the metropolitan a by four companies, which are: The Pacific Telephone Telegraph Company, a part of the Bell Telephone Syst the Associated Telephone Company, Limited; the C fornia Water and Telephone Company; and Sunla Tujunga Telephone Company.

In addition to the primary serving area as descri

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condary area comprised of 12 Orange County ex-
ges is served by the Los Angeles tandem system
ugh interconnecting trunks to and from a small tandem
e in Anaheim.

coming traffic only is handled from more distant toll
ers at Bakersfield, Pomona, San Bernardino, and San
o. Bakersfield and San Diego, which are located 112
s to the north and 126 miles to the south, respectively,
the most remote points having access to the tandem
ities for inward traffic to the Los Angeles area.

e traffic to and from points outside the metropolitan
is increasing to such volume that consideration is being
to handling it through a more comprehensive inter-
dial tandem which is being planned for the future.
such an arrangement in the long-term picture, the
ate scope of the metropolitan area tandem network
be restricted to what was described as the primary
ng area.

ntil automatic ticketing was introduced for inter-exchange service, all calls handled over the tandem system were operator-dialed by either the "A" operator or by the toll operator. With automatic ticketing, the subscriber is permitted to dial directly all points within the metropolitan area, except for six. Three of these are manual exchanges, and three are dial exchanges not yet arranged for using the universal numbering system. Operator-dialed calls may be directed to all points within the terminating scope of the tandem system.

Traffic is generated within the serving areas of 61 switchboards, 15 automatic ticketing offices, five attended pay stations, and the Orange County tandem office. Each originating unit has access to one or more tandem offices, plus direct trunk groups when justifiable.

Tandem development may be traced to the growing volume of metropolitan area interexchange traffic which is shown graphically in Figure 2. A comparison of traffic increase with respect to station gain may be made by referring to Figure 3. Only a part of the total traffic now

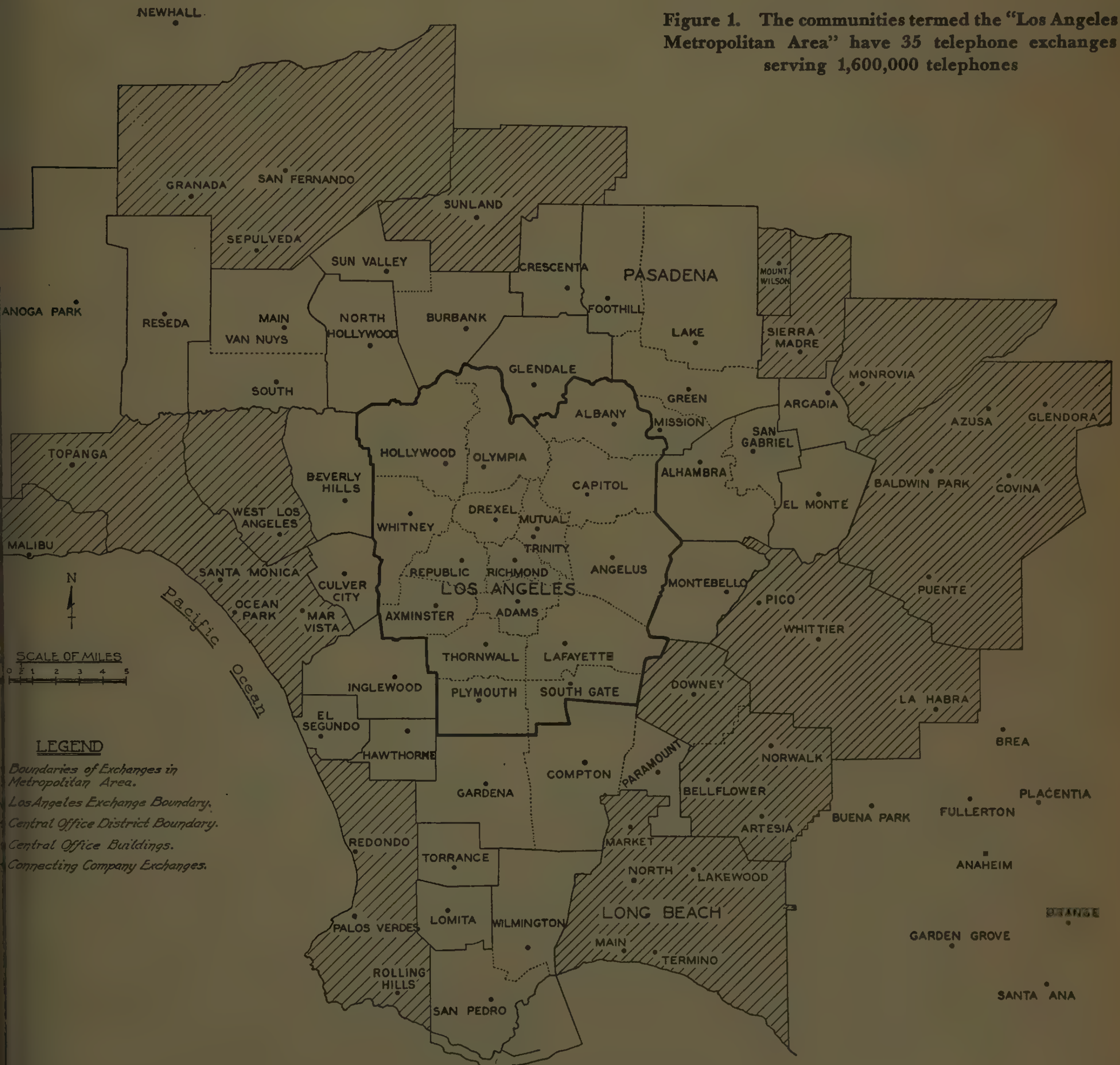

Figure 1. The communities termed the "Los Angeles Metropolitan Area" have 35 telephone exchanges serving 1,600,000 telephones

is of the type handled over the tandem system as the introduction of the extended class of service, beginning in 1934, permitted calls between nearby exchanges within certain mileage limits to be handled as local calls. This in effect placed a portion of the interexchange traffic on a "free" basis to extended service subscribers.

Direct dialing by these subscribers over cross-boundary cable routes thus absorbed part of the growth that would have otherwise taken place in the type of calls handled by the tandem system. A very small amount of this traff remains in tandem routes where cross-boundary dialing not available and operator dialing is substituted. Th remaining portion of the calls are of the type that were a originally classed as short haul toll if placed with the to operator or "A" board toll if placed with the "O" operato but now with extended service a billing schedule of ex change message unit charges has replaced the earlier syster of short haul toll charges. "Person-to-person" or "revers charge" calls are still classed as to calls, as are calls involving poin beyond the metropolitan area. Th kind of traffic handled over th tandem system is therefore prac tically all of the type that involves charge in excess of the monthly rat schedule.

TRUNKING METHODS

IN THE SELECTION of a metho for trunking between telephon exchanges within a metropolita area there are a number of basi relationships to consider. A heav volume of calls over any trun group, for example, will mean tha a larger number of calls per trun can be carried. Conversely, a lo volume of calls will result in fewe calls per trunk as shown in Figure As the length of a circuit is in creased, the requirements as to siz of wire grow progressively more se vere. At the same time the te minal equipment becomes mor complex and expensive in order t cope with such factors as pulsin transmission, or supervision. Th cost penalties of inefficiency wi therefore increase very rapidly a the mileage is extended, unle something can be done to obtain relatively high volume of calls ov each trunk group.

Another element, which is of co siderable importance from an opera ing standpoint, is the effect of th trunking system on switchboa operation. High-speed methods a particularly important where larg call volume develops. Delay resul ing from intermediate manual switc ing methods may be reduced wi automatic dial switching. The nu ber of small trunk groups an oper tor must search over may be reduc by tandem trunking. It also is des able to prevent operators' tande trunk groups from becoming exce sively large because the time requir

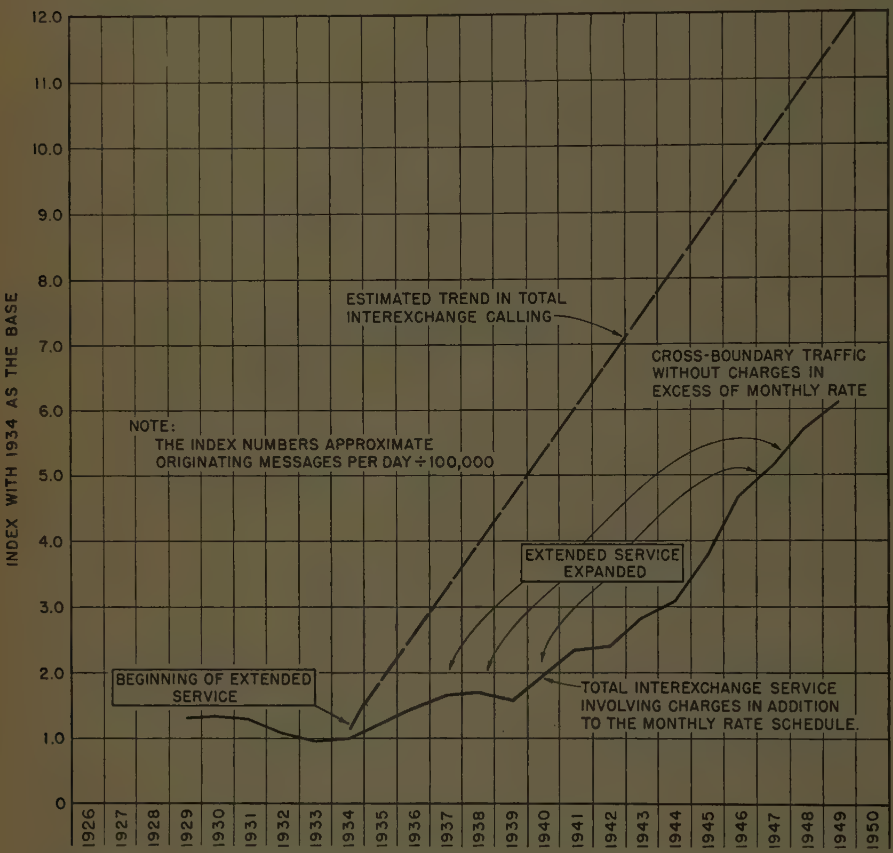

Figure 2. The development of metropolitan area interexchange service

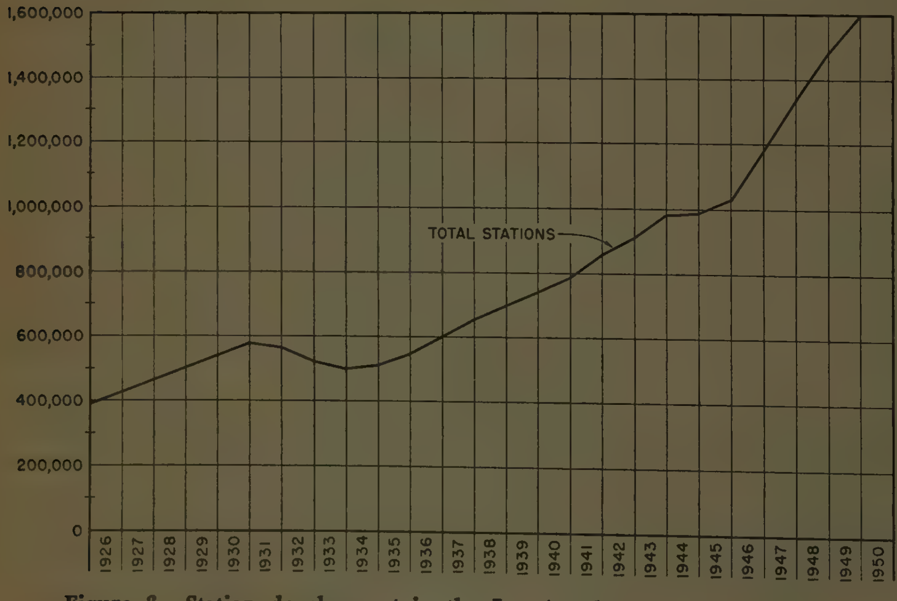

Figure 3. Station development in the Los Angeles metropolitan area

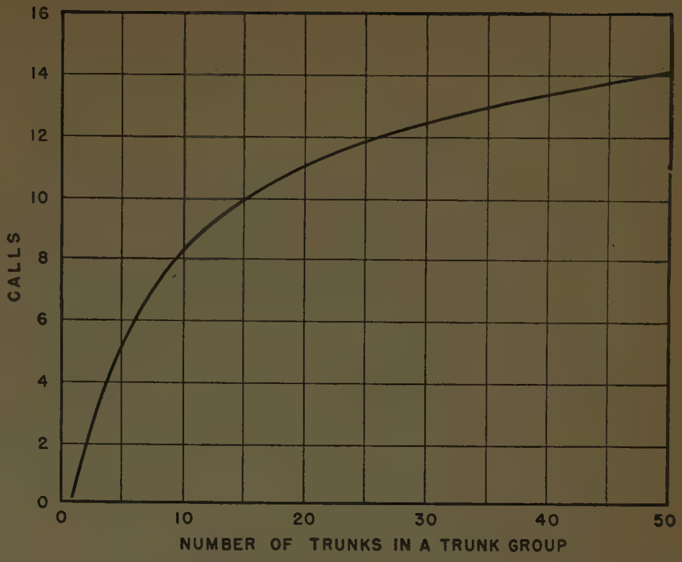

Figure 4. Average load carried in calls per trunk in a trunk group for a probability of loss P = 0.01 and three minutes holding time assumed

find an idle trunk may adversely affect operation. er factors more directly associated with design details e to be considered also, but the main underlying prob- of selecting a trunking method involves a search for ter trunking efficiency, a shorter cable route, or a er method of operation. The various arrangements narily adaptable to the problem are outlined here.

irect Trunking. Direct trunking, as the name implies, uires an individual group of trunks between each pair ffices to be used for the sole purpose of trunking from office to the other. If direct trunks were used ex- ively, $n(n\text{-}1)$ groups of 1-way trunks would be required interconnect n telephone offices as shown in Figure Obviously, the exclusive use of direct trunking would lt in an unreasonably large number of very small k groups and would introduce plant inefficiencies as l as operating difficulties.

here are advantages in direct trunking, however, that not be overlooked. The direct route will, in many s, be substantially shorter and require less complex ipment arrangements. The de- need only be adequate for a cific function, whereas the design multipurpose routing must be erned by the most severe operat- condition. With a fairly high ume of traffic, both efficient oper- n and the benefit of a short, ple routing may be obtained. It uld be noted that growth will duce an increasing volume of s and the long term trend, there- , is toward direct trunking.

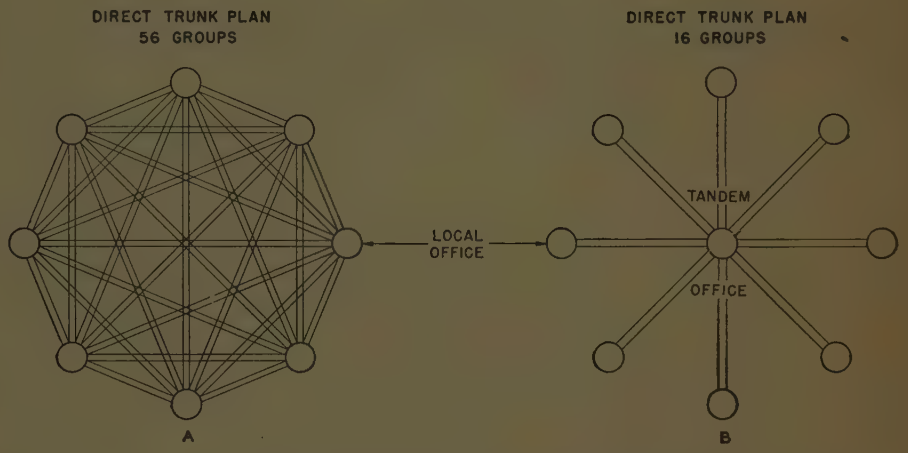

Figure 5. Trunk groups required between eight central offices, (A) direct trunk plan, 56 groups, (B) tandem trunk plan, 16 groups

andem Trunking. Tandem opera- overcomes, to a large extent, disadvantages of direct trunk- through the use of strategically tered auxiliary switching equip- t which is referred to as a tan- office. When each originat- office is provided with tandem trunks, calls may directed via tandem for completion to any point hin its terminating scope. This permits the trunk ps, to and from the tandem, to be relatively large and rate at a much higher efficiency than is ordinarily inable with individual trunk groups. A small number fficient trunk groups can thereby be employed in place large number of inefficient groups. This is demon- ted by a comparison between Figures 5*A* and *B* which e been simplified by assuming 1-way trunk groups and eight offices. By referring to Figure 6, the effect of dem operation and the benefit of larger trunk groups n average trunk efficiency should be obvious.

here are disadvantages to dial tandem trunking that ld be recognized in order that over-all plans may be ed to overcome them. For one thing, the tandem e is an extra central office unit located at the hub of a e and very important trunking network. As such it mes a sort of nerve center for the entire serving area, nearly anything that happens within that area may affect tandem operation. A shift in the predicted pattern of growth, central office prefix changes, new central offices, new operating centers, new trunk routes, and equipment changes are some of the things that require co-ordinated activity in the tandem office. Also, from an economic standpoint, the cost of the tandem switching equipment is an item offsetting at least a portion of the increased trunk efficiency obtained. As pointed out earlier, the long term trend favors direct trunking, and this means that the economic gain obtained by tandem operation may gradually slip away, and for the heavier routings, direct trunking may become more desirable than tandem operation. A continuing study of the resulting problem is required if a balanced plant design is to be maintained.

Direct Trunking with Tandem Alternate Routing. Direct trunking with tandem alternate routing exploits some rather obvious relationships concerning the distribution of traffic between the individual trunks in a group. If traffic is offered, for example, to a group of ten trunks in an orderly manner, the first choice trunk will have an opportunity to handle all calls. The second choice trunk will have an opportunity to handle all calls except those that found the first choice trunk idle and so on to the last choice trunk. By plotting the resulting distribution of traffic, as in Figure 7, the load carried by each trunk can be observed. In this particular case, more than half the traffic is carried by the first three trunks and they are, therefore, quite efficient as direct trunks. In larger groups the effect is even more pronounced. The latter choice trunks are progressively less effective on a direct routing basis, and a very substantial gain is realized when this traffic is mixed with similar overflow traffic in a large common tandem routing. Direct trunks may be selected so that the least efficient direct trunk carries as much or more traffic than the average tandem trunk, or an economic selection of the load to be carried by the least efficient direct trunk can be made by applying the trunk cost ratio. If, for example, the cost for a direct routing is half as much as for a tandem routing, economic balance is obtained when the least efficient direct trunk carries half as much traffic as the average tandem trunk.

There are a great many factors to consider in the practical application of alternate routing systems which involve consideration of the volume and characteristics of traffic and various other engineering or administrative problems. It is clear, however, that direct trunking with tandem alternate routing is an increasingly important element in metropolitan area plant design. This is to be expected since the advantages of both tandem and direct trunking are thus obtained.

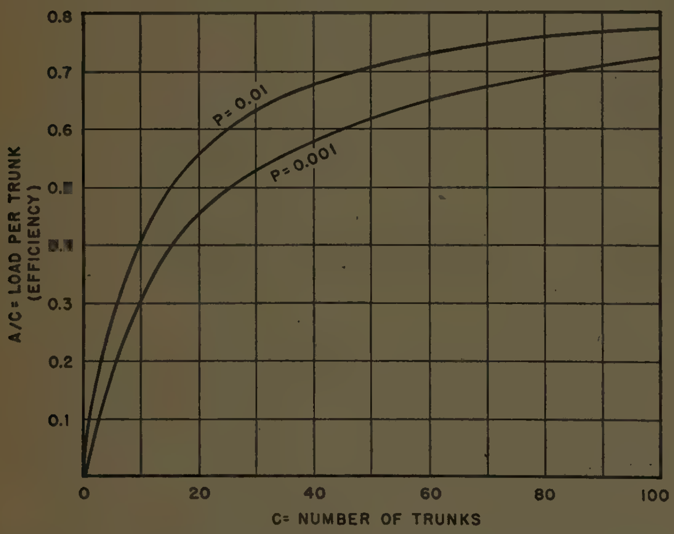

Figure 6. Tandem operation and larger trunk groups increase the average trunk efficiency

DIAL TANDEM NETWORK

IN THE LOS ANGELES metropolitan area, five tandem offices, as will be described here, are utilized to provide switching facilities for trunking between the various exchanges of the area. Two of the tandem offices are located in Mutual Building which is the wire center for the area. The other three tandem offices are strategically located provide coverage for particular sectors of the area.

Los Angeles Mutual Step-by-Step Tandem. This unit whi is usually referred to as the "long haul tandem" was fi placed in service in 1926. Many changes and additio have been required since that time to keep pace with t development of the area, but basically the unit performs t function it was originally designed to accomplish. T present plan employs the following major equipment ite

7,697	selector switches
92	rotary out trunk secondary switch units
3,571	pulse repeaters (20 types)
80	voice frequency repeaters
740	composite sets (7 types)

The general transmission plan for this tandem is sy metrical, and Los Angeles exchange connections are limit to a circuit loss between the subscriber and the tandem 5 decibels for either originating or terminating. The fi fringe offices are limited to 6 decibels and those beyond t first fringe are limited to a 7-decibel loss. Thus the ove all service may be established between subscribers in t various exchanges in accordance with Table I.

Table I. Loss Between Exchanges

Typical Types of Connections	Transmissio Limit, Decib
Los Angeles to first fringe exchanges	11
Los Angeles to outer exchanges	12
Between fringe exchanges	12
Fringe to outer exchanges	13
Between outer exchanges	14

In addition to the outer exchanges within the metr politan area this unit connects with the Orange Coun tandem to serve the following exchanges:

Anaheim
Brea
Buena Park
Fullerton
Garden Grove
Huntington Beach
Laguna Beach
Newport Beach
Orange
Placentia
Santa Ana
Westminster

Incoming trunks are provided for the more dista points, namely, Bakersfield, Pomona, San Bernardin and San Diego, as mentioned previously.

The traffic capacity of this unit is approximately 39,0 calls during the busy hour, assuming an average of abo three minutes per call. These calls originate over appro mately 2,650 incoming tandem trunks.

Since 1926, this tandem unit has been the main switchi center for all operator-dialed and automatic ticketi traffic. It is the only unit with complete access to t entire metropolitan area and Orange County poin Experience with the more recently introduced crossb tandem at Mutual office indicates advantages in ultimat reducing the scope of the step-by-step unit and expandi the coverage of the crossbar unit.

Los Angeles Mutual Crossbar Tandem. At present t unit is referred to as the "short haul tandem." It w first placed in service in January 1948 and immediat took over the function of a small step-by-step short ha dem previously employed for handling traffic between Los Angeles exchange and Pasadena, Glendale, erly Hills, and Culver City. Additional capacity was vided to permit expansion of the area of coverage to ude all points within a range of approximately 2,000 ns trunk resistance. This limited the total scope roughly Los Angeles and contiguous exchanges.

he reasons for initially limiting the coverage of the ssbar tandem were largely for purposes of expediting installation.

full unit of crossbar tandem equipment was installed ially with a capacity of about 28,000 busy hour calls.

he transmission plan for the Mutual crossbar tandem lentical to the Mutual step-by-step tandem.

os Angeles Lafayette Sector Step-by-Step Tandem. The ayette sector tandem is located in Huntington Park roximately six miles south of Mutual office and is along route from Los Angeles to such points as Long Beach, wney, and Compton. It was first cut into service in y 1949 and has capacity for about 10,000 busy hour s.

he main purpose behind the sector tandem idea is to inate back-haul of traffic and thus permit shorter tes and finer gauge trunk cables. The scope of coverage mited and in this case includes the central, southerly, easterly districts of the Los Angeles exchange and ying points. More specifically the area is as follows:

Los Angeles Exchange

ms District
elus District
ninster District
Drexel District
Lafayette District
Mutual District
Republic District
Richmond District
Thornwall District

Other Exchanges

npton
vney
Long Beach
San Pedro
Wilmington

he transmission design of this and all other sector dems is limited to 6 decibels inward plus 6 decibels ward. An over-all loss between subscribers of no more n 12 decibels is therefore obtained.

os Angeles Thornwall Crossbar Sector Tandem. The rnwall sector tandem is located roughly six miles south Mutual office and about four miles west of Lafayette. vas first cut into service in November 1949 with a acity for about 10,000 busy hour calls.

he Thornwall office is along the route from Redondo ch and Inglewood to central office districts in the central, herly, and westerly part of the Los Angeles exchange.

os Angeles Hollywood Sector Crossbar Tandem. The lywood sector tandem was first cut into service in ruary 1950. It is located 6.7 miles northwest of Mutual e and is along the main route to San Fernando Valley ts. It serves exchanges in the sector to the north and of Mutual office.

SUMMARY

IAL TANDEM facilities are employed in the Los Angeles metropolitan area to permit rapid and economical rexchange telephone service over the wide area of subscriber community of interest. The five major tandem offices are part of an over-all system which is designed primarily to

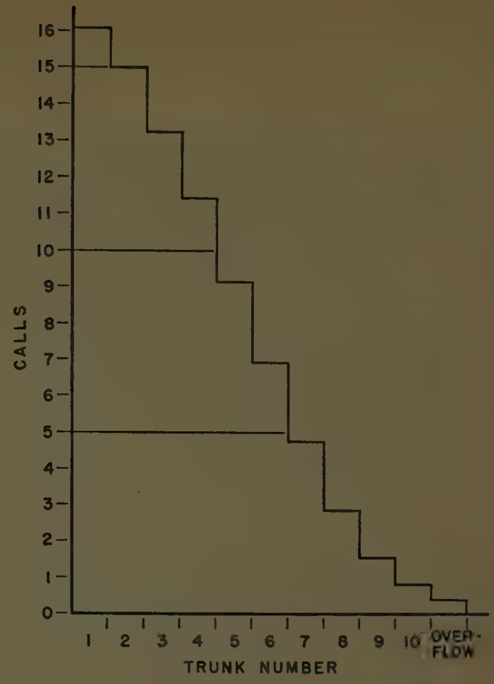

Figure 7. Load in calls carried by each trunk. Erlang "B" basis, 148 equivalent hundred call seconds offered, 180 seconds holding time assumed

1. Provide operating methods that will permit the handling of calls at a speed comparable to a local grade of service.

2. Permit high trunk efficiency and an economically balanced plant design that is consistent with advanced telephone practice.

3. Allow a less exacting plant design than would be required if toll long-distance type facilities were employed, so that the large volume of calls may be handled at minimum cost to the customer.

Two fundamentally different types of equipment are employed and each contributes important advantages in this area. The step-by-step tandem equipment, which is of the same type employed in the local dial offices and around which the dial tandem network has grown since 1926, is best adapted to stable conditions or small units. The more recently developed crossbar tandem with its highly flexible trunking arrangements is a valuable tool for meeting the requirements of the most volatile service demands. It also includes features which extend the idea of service protection beyond reliance upon high grade preventive maintenance to include the conception of self-checking and prompt completion of calls even under many trouble conditions.

While long-term growth tends to increase the effectiveness of direct trunking methods over tandem trunking, other adverse trends are constantly causing additional segregations in the traffic. As a result, the effectiveness of interexchange trunking methods remains dependent upon the tandem switching system.

Motionally Induced Electric Fields—Part VI

Motional Field Inside Moving Iron Tube

Jack, the physicist, is continuing his lectures to Alter Ego and his friends on the basic principles underlying dynamo-electric machines. Jack has altered the meaning of **v** in his universal equation $\mathbf{E}_{\text{mot}} = \frac{1}{c}[\mathbf{v} \times \mathbf{B}]$ to now be the "relative velocity of the body and the magnetic field." He is now considering how to save his universal equation for the force on a current carrying body, $\mathbf{F}_m = [\mathbf{i} \times \mathbf{B}]$, when applied to an iron bar carrying current density **i** in an otherwise uniform magnetic field $\mathbf{B}_0$.

Jack: "You have forgotten, Alter Ego, the discussion we had at lunch some months ago on the forces on iron in a magnetic field (*EE, June '50, p 550*). We all agreed that a piece of iron of itself when placed in a nonuniform magnetic field would experience a force tending to move it from the weaker field towards the stronger. We had some disagreement as to just what the details of that force would be. I said that the force arose from the action of the field on the amperian currents, $\mathbf{i}_{\text{amp}} = \text{curl } \mathbf{M}$, where **M** is the magnetization density. Bill, however, said it was due to the apparent magnetic charge, $\rho_m' = -\text{div } \mathbf{M}$, being acted upon by the magnetic field **H**, and Charlie said that it was due to the magnetic doublet density **M** being acted on by the nonuniform field $\dot{\mathbf{H}}$. In any case, when we calculated the force on a total body we came to the same total result, in spite of our different equations, and we would agree that an iron body would be pulled in the direction from the weaker field to the stronger field.

"Now in the case we are considering, when we pass current through the bar, lying in the otherwise uniform field, we strengthen the field on one side of the bar and weaken it on the other. The force arising from the curren will be

$$\mathbf{F}_m = [\mathbf{i} \times \mathbf{B}] \qquad (1$$

and will tend to move the bar from the strengthened fiel to the weakened field. However, as I have just said because of the magnetization of the bar **M**, there wi also be a force depending on **M**, tending to pull the bar i the opposite direction, namely from weak field to strong Thus, the gain in the force $\mathbf{F}_m = [\mathbf{i} \times \mathbf{B}]$ which **M** bring about because it strengthens **B** from its original valu $\mathbf{B}_0$ is compensated by the tendency from the magnetize bar with magnetization **M** to move from the weak field t the strong. This force is calculable by my equation

$$\mathbf{F}_J = [(\text{curl } \mathbf{M}) \times \mathbf{B}] \qquad (2$$

or by Charlie's equation

$$\mathbf{F}_C = -\mathbf{H} \text{ div } \mathbf{M} \qquad (3$$

or by Bill's equation

$$\mathbf{F}_B = \mathbf{M} \cdot \nabla \mathbf{H} \qquad (4$$

"If you use any one of these equations with equation and integrate over the whole bar, you will find that th total net force remains the same as if **M** had not develope or as if the force per unit volume had remained $\mathbf{F}_m =$ $[\mathbf{i} \times \mathbf{B}_0]$."

Alter Ego: "Then there was no use in my increasin **B** in my one coil side by making it of iron, since the increas in **B** only brought about a corresponding decrease in th relative velocity **v** so that $[\mathbf{v} \times \mathbf{B}]$ did not change. How ever, I have another form of my invention, where I reduc **B** on the one coil side to practically zero by slipping hollow cylinder of extremely high permeability iron aroun it, as in Figures 1 and 2. The lines of force of the magneti field are completely shunted away from the coil side by th iron tube which moves along with it. Now, with you new interpretation of **v** in your universal equation fo $\mathbf{E}_{\text{mot}}$, you must make the lines of the magnetic field whi across the coil side inside of the iron cylinder with a increased relative velocity **v** such that

$$\frac{1}{c}[\mathbf{v} \times \mathbf{B}] = \frac{1}{c}[\mathbf{v}_0 \times \mathbf{B}_0] \qquad (5$$

where $\mathbf{v}_0$ is the actual velocity of the coil side, and $\mathbf{B}_0$ th intensity of the otherwise uniform field. But with re high permeability iron, I can reduce **B** inside the iron tub to practically zero, so you will have to make **v** the relativ velocity of the magnetic lines and the coil sides practicall infinite if you want equation 5 to hold. I don't thin you'll like that, Doctor Jack, since you once told me tha it is impossible to have a relative velocity greater than th velocity of light. If **v** has to stay finite, then with **B** equa to zero the motional electromotive force in that coil sid will be zero, and the total motional electromotive force the whole coil translating in the otherwise uniform fiel

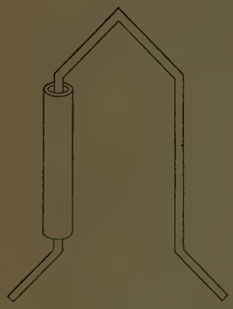

Figure 1. Iron tube encircling coil side

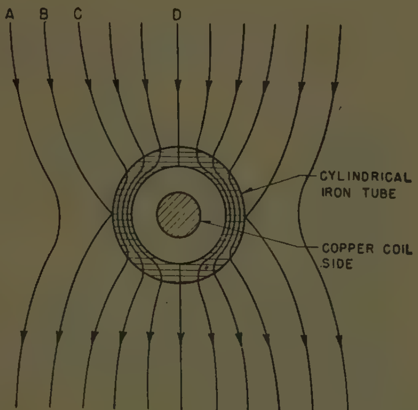

Figure 2 (right). Coil side in iron tube in magnetic field

not be zero, and I'll get back my commutatorless d-c erator.

Now if I send current through the coil, the side inside tube being in zero magnetic field will have zero force t, whereas the other coil side will have the full $\mathbf{F}_m=$ $\mathbf{B}_0]$ on it, so now I get back my commutatorless d-c erator and space ship."

ack: "It is true that the force on the coil side inside iron tube will be zero, but there will be a force on the tube itself. When current flows in the coil, the tube be in a nonuniform field, and it will want to move from weaker field to the stronger. If you will use my ation, or Bill's, or Charlie's for the force on iron in a netic field, you will find that it is exactly equal to $\mathbf{B}_0]$ integrated over the coil side. The total force on whole coil plus iron tube will be zero, so that again r commutatorless motor and space ship are ruined. ollows then from the principle of conservation of energy your commutatorless generator must fail too.

But I see now that I am still not interpreting the ersal equation $\mathbf{E}_{mot}=\frac{1}{c}[\mathbf{v} \times \mathbf{B}]$ rightly since I certainly not want any infinite $\mathbf{v}$. Perhaps this is the way it ld be done. Perhaps we should consider how the netic field which acts on the moving bar originates. original uniform field $\mathbf{B}_0$ is due to some stationary net or field structure and is at rest. When we use the slide bar, the bar becomes magnetized, and its magnetion $\mathbf{M}$ by itself would produce a field $\mathbf{B}_1$. The field however, moves along with the magnetized bar so that elocity relative to the bar is zero. The total field is $\mathbf{B}_0+\mathbf{B}_1$, but because the relative velocity of the bar to $\mathbf{B}_0$ and to $\mathbf{B}_1$ is zero, the motional field in the bar is

$$=\frac{1}{c}[\mathbf{v}_0 \times \mathbf{B}_0] \qquad (6)$$

Similarly for the iron tube. The zero resultant field $\mathbf{B}$ le the tube is really the sum of the stationary field $\mathbf{B}_0$ an equal and opposite field, $\mathbf{B}_1=-\mathbf{B}_0$, which is set by the magnetization of the tube, and which moves g with the tube. Since the relative velocity of the to $\mathbf{B}_1$ is zero, and to $\mathbf{B}_0$ is $\mathbf{v}_0$, the motional field in the will still be given by equation 6.

In the general case, we look around and examine the ins of the magnetic field $\mathbf{B}$ in which our body is exencing its motional electric field. We may find that e is one component of field, $\mathbf{B}_1$, which arises from a ent-carrying coil which is moving with velocity $\mathbf{v}_1$. field $\mathbf{B}_1$, of course, moves along with the coil, and efore also has the velocity $\mathbf{v}_1$. Another part of the l, $\mathbf{B}_2$, may originate in a magnetized body moving velocity $\mathbf{v}_2$, so $\mathbf{B}_2$ also has the velocity $\mathbf{v}_2$. And so on. v, if we have a body moving with the velocity $\mathbf{v}$ in the l field, $\mathbf{B}=\mathbf{B}_1+\mathbf{B}_2+\ldots\ldots$, since it is the relative city of the body to each component field which really nts, we have for the motional electric field in the body

$$=\frac{1}{c}[(\mathbf{v}-\mathbf{v}_1) \times \mathbf{B}]+\frac{1}{c}[(\mathbf{v}-\mathbf{v}_2) \times \mathbf{B}_2]+\ldots$$

$$=\frac{1}{c}[\mathbf{v} \times \mathbf{B}]-\frac{1}{c}[\mathbf{v}_1 \times \mathbf{B}_1]-\frac{1}{c}[\mathbf{v}_2 \times \mathbf{B}_2]\ldots \qquad (7)$$

"This equation 7 will take care of your iron slide bar and of your iron-encircled copper slide bar, Alter Ego."

(*To be continued*)

Question 1. Jack's interpretation of this motional electric field equation is getting quite complicated. Will this resolving of the actual field into variously moving component fields get Jack out of his troubles?

Question 2. To calculate the force on Alter Ego's iron structures carrying current in an otherwise uniform magnetic field, Jack offered several alternative equations, saying that they each individually would lead to the same remarkable result of the cancelling out of any effect arising from the magnetization on the total force on the current-carrying structure. These individual equations would give different volume distributions of force over the structure, and it seems odd that they should all add up to the same remarkable zero resultant.

Is there not some more direct way of calculating the total force which will not inquire into these dubious volume distributions of force and which will give the total force from the externally observable fields?

J. SLEPIAN (F '27)

(Westinghouse Research Laboratories, East Pittsburgh, Pa.)

Ballast

An electrical engineer wishes to connect a single-phase impedance load to a distribution line. The load is defined by its kilovolt-ampere rating and its power factor—cos θ, its impedance $z=r+jx$ ohms, and its admittance $y=g-jb$ mhos. The engineer finds that the line is restricted to supplying balanced 3-phase loads only. Thereupon he designs a ballast as shown in Figure 1. The combined load and ballast draw a balanced 3-phase current from the line at unity power factor. What are the kilovolt-ampere ratings of the elements of the ballast expressed as a fraction of the load kilovolt-amperes (base), and their ohm and mho values?

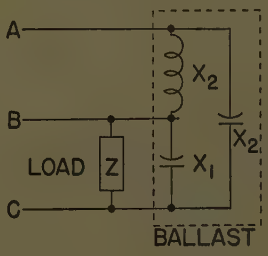

Figure 1. The ballast shown here and the load draw a balanced 3-phase current from the line

A. A. KRONEBERG (F '48)

(Southern California Edison Company, Los Angeles, Calif.)

Seven Networks

The engineer from the land of pure electrical constants is preparing an exhibit to illustrate a talk on equivalent circuits, one in a series of talks on Heaviside's operators in

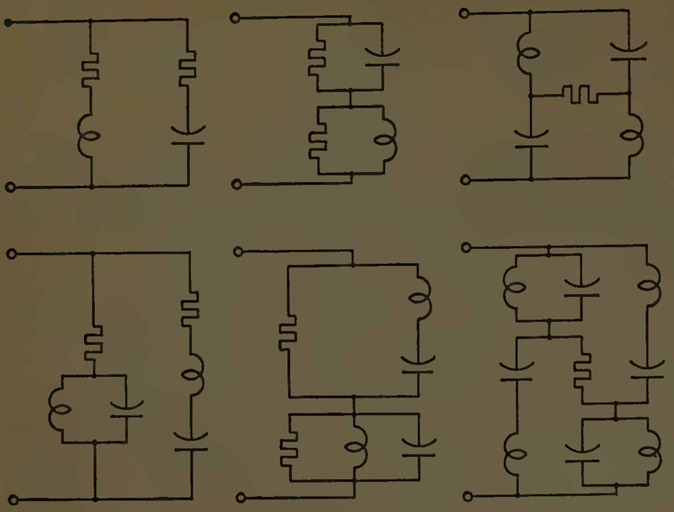

Figure 1 (above). Six networks

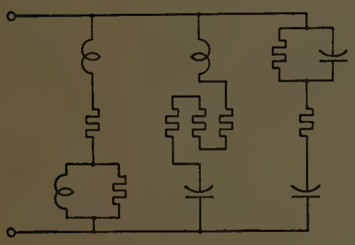

Figure 2 (left). Seventh network

engineering and physics. He uses inductors of L henrys, capacitors of C farads, and resistors of $R=\sqrt{L/C}$ ohms in assembling the six networks shown in Figure 1.

From elements remaining on hand, he then assembles the seventh network illustrated in Figure 2. Does this network belong in the same group with the other six networks?

A. A. KRONEBERG (F '48)

(Southern California Edison Company, Los Angeles, Calif.)

Answers to Previous Essays

Motionally Induced Electric Fields—Part V. The following is the author's answer to his previously published essay (*EE, Mar '51, p 254*).

As Part VI of the series shows, Jack is in an awful mess with his idea of moving lines of magnetic force.

The author has several times now stressed that the electric and magnetic fields in Maxwell's Theory are vector fields and nothing more.[1–4] A vector field associates each point of metrical space with a direction and a magnitude, and that is all. Now, we are accustomed to picture electric and magnetic fields by means of assemblages of lines of force, these lines of force at all points of space having the same direction as the vectors they are portraying, and the density of the lines of force being chosen so as to be proportional to the magnitude of the vectors they are portraying. If necessary, in order to keep up this correspondence between line density and vector magnitude, we end lines or start new lines in the various regions of space. The excess of the number of new line beginnings over line endings per unit volumes is thus proportional to the divergence of the vector field being portrayed.

Now, however, if we are not careful, we will assume that certain properties of these lines of force, which we introduce into any particular choice of lines of force which we may make, are also significant or pertinent to the vector fields which they represent even though such properties are not in themselves in the vector field. Such properties are continuity and individuality of the lines. These properties correspond to no properties of the bare vector field, which is all that appears in Maxwell's equations.

Considering continuity first, we may at any place in our line-of-force diagram break off the lines of force we may have been using, and which are approaching the region, and start off a set of completely new lines with the same density. The broken lines represent the vector field just as well as the continuous lines, since they have the same density and direction. The excess of line beginnings over line endings thus introduced is zero, so that the correspondence with the vector field divergence is not altered. Thus, continuity of the lines in a line-of-force representation is an irrelevant property as far as electromagnetic phenomena are concerned. Any deduction concerning electromagnetic phenomena, which depends on the continuity of the lines of force of a field representation, may be false. As a matter of fact, a line-of-force representation with completely continuous lines of force everywhere is not possible, except for very special electric and magnetic fields.[1,2,4]

Similarly for the notion of the individuality of a line, a concept not independent of the property of continuity. In a temporal succession of lines-of-force representations, we may correlate a particular line in one picture with a particular line in a later picture and assert that it is the same line. But such an assertion can have no verifiable significance or pertinence to electromagnetic phenomena. We may, if we like, assign continuing identifiable individuality to lines in such a way that the lines execute a most intricate dance among themselves, provided only that we keep their density and direction always corresponding to the field they are portraying. Such intricately dancing lines will portray the field just as well as more sedate line assemblages. However, any deduction concerning electromagnetic phenomena which depends upon either dancing proclivities or sedateness of the lines of force may be false. The lines of force are related to the vector fields which they portray like the colors on a map to the actual country which is being portrayed. The boundary line between pink Pennsylvania and yellow Ohio on the map is very pleasingly made evident, but any expectation of finding something corresponding to pinkness and yellowness in actual Pennsylvania and Ohio is doomed to disappointment.

Now Jack, in trying to rescue his "universal" motional field $\mathbf{E}_{\text{mot}}=\frac{1}{c}[\mathbf{v}\times\mathbf{B}]$ by the device of moving lines as in part IV of this series,[5] is clearly using the notions of continuity and individuality of lines of force, which have no relevance to electromagnetism. Conclusions which he may draw then may be false. As a matter of fact, his umption that the ends of the magnetic lines of force note from the iron bar are stationary is not only without ifiable physical meaning but it is also entirely arbitrary. might just as well have let these remote line ends dance ong themselves as he pleased, provided he kept their nsity constant. Then he would be seeing quite other tional electric fields in the iron bar, and he would also "motional electric fields" in stationary parts of the cuit.

metallic body, for which Ohm's Law, $\mathbf{i}=\sigma\mathbf{E}$ and =0, holds when it is at rest, will have the constitutive uation when it is moving

$$\left(\mathbf{E}+\frac{1}{c}[\mathbf{v}\times\mathbf{B}]\right) \qquad (1)$$

ere $\mathbf{v}$ is the translational velocity of the body itself ative to a suitable material frame of reference. For h a body if it is nonmagnetic, we may say that in tion it behaves, as far as current flow is concerned, as t were at rest, in the same steady field $\mathbf{E}$, with an addinal field $\frac{1}{c}[\mathbf{v}\times\mathbf{B}]$ acting on it. In that sense, and t case, we might talk of a "motional field" $\frac{1}{c}[\mathbf{v}\times\mathbf{B}]$.

t for a magnetic body, even in an unchanging field, and a nonmagnetic body in a varying field, $\mathbf{E}$ for the body rest cannot stay the same as $\mathbf{E}$ for the body in motion, l so calling $\frac{1}{c}[\mathbf{v}\times\mathbf{B}]$ the "motional field" is no longer tified, since the motion of the body also causes a change in For other bodies such as, for example, an insulator h the constitutive equations

$$\frac{1}{c}[\mathbf{v}\times\mathbf{H}]=\epsilon\left(\mathbf{E}+\frac{1}{c}[\mathbf{v}\times\mathbf{B}]\right)$$

$$\frac{1}{c}[\mathbf{v}\times\mathbf{D}]=\mathbf{B}-\frac{1}{c}[\mathbf{v}\times\mathbf{E}] \qquad (2)$$

cannot at all say that the effect of the motion is the same introducing an additional electric field $\frac{1}{c}[\mathbf{v}\times\mathbf{B}]$. For h other bodies the idea of a universal "motional field" quite without meaning.

We have seen[6] that for any closed curve, the points of ich move with arbitrarily assigned velocity $\mathbf{u}$

$$\left(\mathbf{E}+\frac{1}{c}[\mathbf{u}\times\mathbf{B}]\right)\cdot d\mathbf{s}=-\frac{1}{c}\frac{d}{dt}\int\!\!\int\mathbf{B}\cdot d\mathbf{S} \qquad (3)$$

follows then that in a metallic circuit of total resistance under conditions such that the total current I in it is same throughout its length (that is, no charging rents)

$$=-\frac{1}{c}\frac{d}{dt}\int\!\!\int\mathbf{B}\cdot d\mathbf{S} \qquad (4)$$

Now, under these same conditions, Jack's revised version his "motional field" given in the preceding essay,[5] when egrated around the metallic circuit, will equal the rightnd member of equation 4, and therefore will also equal This will also be the case if he lets his lines of force dance around arbitrarily as mentioned before. Thus it would seem as if Jack's device might take care of metallic circuits, whether magnetic or not, moving in fields which would be otherwise constant. It would seem then that Jack's trick might be sufficient for the usual dynamoelectric machine and perhaps also for any modification of such machine that Alter Ego might propose. However there is still a serious difficulty that Alter Ego's next invention will bring out.

REFERENCES

1. Answers to Previous Essays, **J. Slepian.** *Electrical Engineering*, volume 68, September 1949, page 763.
2. Answers to Previous Essays, **J. Slepian.** *Electrical Engineering*, volume 68, October 1949, page 878.
3. Answers to Previous Essays, **J. Slepian.** *Electrical Engineering*, volume 68, November 1949, page 985.
4. Lines of Force in Electric and Magnetic Fields, **Joseph Slepian.** *American Journal of Physics* (New York, N. Y.), February 1951, pages 87–90.
5. Motionally Induced Electric Fields—Part IV, **J. Slepian.** *Electrical Engineering*, volume 70, February 1951, pages 159–60.
6. Answers to Previous Essays, **J. Slepian.** *Electrical Engineering*, volume 70, March 1951, equation 15, page 256.

J. SLEPIAN (F '27)

(Westinghouse Research Laboratories, East Pittsburgh, Pa.)

Metallurgical Advisory Board

Formation of a board of leading industrial and academic metallurgists to advise the Research and Development Board, Department of Defense, on research aspects of some of the nation's most critical metals problems was announced recently. The new Advisory Board's work will be directly in the interest of national security since metals in large quantities are essential for modern military operations.

The Board was organized by the National Academy of Sciences—National Research Council under a contract with the Research and Development Board.

Within the limits of specific problem assignments, the metallurgists are to advise the Board on the correlation, co-ordination, interpretation, and application of metals' research and development programs conducted or sponsored by the Military Services, suggest new research projects or reorientation of existing research, and collect and distribute such useful metallurgical information as can be gathered by the establishment of close liaison with the professional societies, governmental agencies, and academic and industrial organizations devoted to metals and their use.

Preliminary work by the Metallurgical Advisory Board is already in progress on research and development phases of three of the most urgent metals problems: critical and strategic metals and their substitutes; the application of metals to be used at high temperatures; and the development of the presently small titanium industry.

A permanent secretariat and special project committees are to assist the Metallurgical Advisory Board, which also will have the co-operation of the military services, the Munitions Board, and other Federal agencies.

INSTITUTE ACTIVITIES

AIEE Southern District and Student Branch Meetings to Be Held Concurrently

The Southern District and Student Branch Meetings will be held in Miami Beach, Fla., April 11–13, with headquarters for the meeting at the MacFadden-Deauville Hotel.

The opening session at 10:00 A. M. will be addressed by Mayor Harold Turk, who will welcome the visitors to Miami Beach, and AIEE President Titus G. LeClair, who will present an address. The technical papers will be read at two parallel sessions held on the mornings of April 12 and 13, one being devoted to power subjects and the other to such topics as microwave communication, radar and loran, electric home heating, street and highway lighting, and so forth.

The Student Branch Meeting will be held concurrently at the same hotel on April 11 and 12, and a feature of the banquet on April 12 will be the award presentations for Student Papers given at this meeting. (See story on District 4 Student Convention on page 361.)

The quarterly meeting of the AIEE Board of Directors will be held April 12 at the headquarters hotel.

The Illuminating Engineering Society will hold its Southern Regional Conference April 9 and 10 in Miami Beach, with headquarters at the Atlantis Hotel, Miami Beach, and Institute members who are interested in this conference can plan to attend it in conjunction with the AIEE Southern District Meeting.

INSPECTION TRIPS

A program of inspection trips has been arranged, which was described in *Electrical Engineering*, March 1951, page 259. The time and cost of these trips are as follows:

Cutler Steam Electric Station, Florida Power and Light Company, April 12, 1:30–4:30; cost $1.00.

Eastern Airlines, April 13, 1:30–4:30; cost $1.00.

United States Weather Bureau and Television Station WTVJ, April 11, 2:30–5:00; cost $1.00.

Biscayne Bay Sight-Seeing Tour, April 12, 1:30–4:30; cost $2.00.

Greater Miami Tour, April 13, 1:30–5:00; cost $2.50.

Since it is necessary to provide for accommodations in advance, members should indicate on the advance registration card those events which they plan to attend. Tickets for the trips will be available at the time of registration and should be purchased then.

LUNCHEON

A luncheon will be held at 12:30 P. M., Wednesday, April 11, at the MacFadden-Deauville Hotel. Professor F. H. Pumphrey, Chairman of the Florida Section, will preside. Advance registration should be indicated. Tickets will be $2.50 per person, and should be purchased at the time of registration.

BUFFET AND WATER SHOW

At 7:00 P. M. Wednesday a buffet supper will be held in the swimming-pool area of the MacFadden-Deauville. Following the buffet supper, from 8:30 to 9:30 P. M., a Water Show will be presented for the members. Dancing in the Palm Roo will start at 9:30. Tickets will be $4.50 pe person, and will be available at time o registration. Advance registration should b indicated.

BANQUET

The Banquet will be held at headquarter hotel Thursday evening at 7:30. Th price of tickets will be $6.00 per person fo members and guests and $3.00 per perso for Student members. Advance registratio is requested. Tickets should be purchase at time of registration.

LADIES' ENTERTAINMENT

A program has been arranged for th ladies beginning with a luncheon to be hel

The Cutler Steam Electric Station, situated on Biscayne Bay nine miles south of Miami, is unique in that it is the outdoor type of construction. The plant has a total capability of 80,000 kw. A visit to this station will be one of the interesting inspection trips which have been planned for those attending the AIEE Southern District Meeting

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Future AIEE Meetings

Southern District Meeting (*page 354*)
MacFadden-Deauville Hotel, Miami Beach, Fla.
April 11–13, 1951
(*Final date for submitting papers—closed*)

AIEE Textile Conference (North) (*page 362*
Engineers Club, Philadelphia, Pa.
April 23, 1951

AIEE Textile Conference (South) (*page 362*
Georgia School of Technology, Atlanta, Ga
April 26–27, 1951

North Eastern District Meeting (*page 356*)
Hotel Syracuse, Syracuse, N. Y.
May 2–4, 1951
(*Final date for submitting papers—closed*)

AIEE Conference on Domestic Appliance
Battelle Memorial Institute, Columbus, Ohi
May 15, 1951

Great Lakes District Meeting (*page 358*)
Loraine Hotel, Madison, Wis.
May 17–19, 1951
(*Final date for submitting papers—closed*)

Summer General Meeting (*page 360*)
Royal York Hotel, Toronto, Ontario, Canad
June 25–29, 1951
(*Final date for submitting papers—closed*)

Pacific General Meeting
Multnomah Hotel, Portland, Oreg.
August 20–23, 1951
(*Final date for submitting papers—May 21*)

AIEE Conference on Aircraft Equipment
Los Angeles, Calif.
October 8–10, 1951

AIEE Conference on Fractional Horsepower and Motor Applications to Refrigeration Equipment and Pumps
Dayton, Ohio
October 11–12, 1951

Fall General Meeting
Hotel Cleveland, Cleveland, Ohio
October 22–26, 1951
(*Final date for submitting papers—June 22*)

Tentative Technical Program

Southern District Meeting, Miami Beach, Fla., April 11–13

lnesday, April 11

) a.m. Opening Session

l Welcome. Mayor Harold Turk, Miami Beach,
Address. Titus G. LeClair, AIEE President

ırsday, April 12

a.m. General Group

!. 940–960 Megacycle Communications Equip- for Industrial Applications. *F. B. Gunter*, ıghouse Electric Corporation. Presentation by nly

5. Application of Microwave Channels. *R. ɛek*, Westinghouse Electric Corporation

Florida: Communication Gateway to the bean. *I. S. Coggeshall*, The Western Union raph Company

Telegram Handling by Facsimile. *H. H. nd*, The Western Union Telegraph Company

The Use of Radar for Hurricane Location. *. Latour*, University of Florida

Recent Developments in Loran. *A. W. n, J. M. Barney*, University of Florida

A Low Frequency Polar Vector Indicator. *Nottingham, Jr.*, Georgia Institute of Technology

The Engineering Design and Construction omic Power Plants. *D. W. Cardwell*, Oak Ridge nal Laboratory

Silicone Rubber—A Resilient Dielectric. *J. xter*, Dow Corning Corporation

) a.m. Power Group

Modern High-Voltage High-Capacity Circuit ers. *W. M. Leeds*, Westinghouse Electric Cor- on

Power System Relaying. *G. L. Dibble*, South ina Electric and Gas Company

Fundamentals of A-C Circuit Interruption. *Salzer*, Allis-Chalmers Manufacturing Company

6. Vibracode System of Supervisory Control on rier Communication Channel. *T. J. Allen, Joel* , Georgia Power Company

DP.** **Considerations in Selecting a Carrier Relaying System.** *R. C. Cheek, J. L. Blackburn*, Westinghouse Electric Corporation

51-147—ACO.* **The Measurement of the Impedance of Large Substation Grounds.** *L. E. Smith*, Tennessee Valley Authority

51-148. An Analysis of Grounding Banks to Balance Distribution Feeder Voltages. *L. W. Long*, North Carolina State College

DP.** **A Self-Excited Thyratron Inverter.** *R. W. Sampson*, University of Florida

51-149—ACO.* **A Compensated Thermal Anemometer and Flowmeter.** *C. E. Hastings, C. R. Weislo*, Hastings Instrument Company, Inc.

Friday, April 13

8:30 a.m. General Group

51-150. Electric Home Heating. *E. E. Parks*, Nashville Electric Service

DP.** **Electric Steam and Hot Water Accumulators.** *A. C. Gibson*, Nashville Electric Service

DP.** **High Temperature Induction Heating of Non-Magnetic Metals.** *D. C. White, H. A. Owen*, University of Florida

DP.** **Determination of Instantaneous Currents and Voltages by Means of Alpha, Beta and Zero Components.** *W. C. Duesterhoeft, Max Schultz, Edith Clarke*, University of Texas

DP.** **Analysis of Performance of a Modern Sectional Electric Paper Machine Drive.** *R. R. Baker*, Westinghouse Electric Corporation

DP.** **The Amplidyne: Antecedents and Theory.** *Clarence B. Grund, Jr.*, The Alabama Polytechnic Institute

DP.** **Street and Highway Lighting.** *R. J. Swackhamer*, General Electric Company

DP.** **The Bare Facts of Light.** *H. L. Logan*, Holophane Company, Inc.

8:30 a.m. Power Group

DP.** **Modern Electrical Cable Insulating Materials.** *E. W. Davis*, Simplex Wire and Cable Company

DP.** **Present Applications of Silicone Electrical Insulation.** *G. E. McIntyre*, Dow Corning Corporation

DP.** **An Installation of 15-Kv Polyethylene Cable.** *L. W. Roush*, Union Carbide and Carbon Corporation

DP.** **Field Lashing of Aerial Cables.** *F. E. Treat*, Florida Power and Light Company

DP.** **Cathodic Protection for the Florida Area.** *T. G. Hieronymus*, Radiation Laboratories, Inc.

DP.** **Corrosion and Cathodic Protection in the Miami Area.** *C. M. Broom*, Florida Power and Light Company

DP.** **Safety Grounding Neutrals for Low-Voltage A-C Power Systems Using Dry-Disc Rectifiers.** *L. H. Harrison*, Bureau of Mines

DP.** **Thermal Limitations—A Poor Criterion for Loading Distribution Circuits.** *F. G. Hamner, G. B. Campbell*, Southern Services, Inc.

): Advance copies only available; not intended blication in *Transactions*.

': District paper; no advance copies are ble; not intended for publication in *Transactions*.

—PAMPHLET reproductions of author's manuscripts of the numbered papers listed in the program may be obtained from AIEE Order Department, 33 West 39th Street, New York 18, N. Y., as noted in the following paragraphs.

—PRICES for papers, irrespective of length, are 30 cents to members (60 cents to nonmembers) whether ordered by mail or purchased at the meeting. Mail orders are advisable, particularly from out-of-town members, as an adequate supply of each paper at the meeting cannot be assured. Only numbered papers are available in pamphlet form.

—COUPON books in nine-dollar denominations are available for those who may wish this convenient form of remittance.

—THE PAPERS regularly approved by the Technical Program Committee ultimately will be published in Proceedings and Transactions; also, each is scheduled to be published in Electrical Engineering in digest or other form.

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onjunction with a fashion show at 0 on April 11. Price for tickets will be) per person; advance registration is ssary. Tickets should be purchased at ime of registration. A shopping tour anned for Thursday morning on famous oln Road. Friday morning canasta bridge will be the order of entertain- . Side trips to points of interest can rranged.

order to provide accommodations for rips Thursday and Friday morning, it be necessary to make reservations ving the Wednesday Fashion Show. dies are invited on all the afternoon ction and sight-seeing tours listed.

RECREATIONAL PROGRAM

olfers will find both the Bayshore and nandy Shores Golf Courses open to attending the meeting with no green harges. Arrangements for the many available sight-seeing trips by bus or boat as well as bay-bottom and Gulf Stream fishing trips can be made when registering at the meeting headquarters. Likewise, postmeeting tours to either beautiful Nassau in the Bahamas, or Havana, Cuba, by boat or air are available at headquarters.

HOTEL ACCOMMODATIONS

The headquarters hotel will handle all reservations. It will not be possible to house all of those attending in the headquarters hotel and blocks of rooms have been set aside by neighboring hotels (within two blocks of the MacFadden-Deauville). Address all requests to MacFadden-Deauville Hotel, Collins Avenue at 67th Street, Miami Beach, Fla. Confirmation will be made directly by the hotel and if space is confirmed in a co-operating hotel, the name and address of the hotel will be given so that those attending may check in to the proper hotel without stopping at the headquarters hotel first. Copies of reservation requests should be sent to Mr. Ollie T. Ayers, Chairman Hotel and Reservation Committee, Box 3100, Miami, Fla. Parking facilities for those motoring to the meeting are available in the vicinity of the headquarters hotel on commercial parking lots only at fees ranging from $1.00 to $1.50 per day.

The Students will be housed at the Northshore Hotel, but will be welcome to join in all of the District Sessions and Trips.

Members who have children with them can arrange for "baby sitters" with the Social Director of the hotel.

The headquarters hotel and co-operating hotels have set the following schedule of rates:

Single	$5.00 per day
Double	7.00 per day
Triple	9.00 per day

European Plan, run-of-the-house rooms

For those who may wish to stay in motel accommodations, the following motels with their rates are given:

Tickets for the luncheon on April 11, Buffet Supper and Water Show on April 11, Banquet on April 12, and vari[illegible]nned

Motel	Address	Rates
Golden Arrow Motel	15600 Collins Avenue	$6.00 per day, room for 2
Montgomery Motel	15720 Collins Avenue	$6.00 per day, room for 2
Prince Royal.	15810 Collins Avenue	$4.00 per day, room for
Kimberly Motel	158th Street & Collins Avenue	$10.00 per day, room for 2
Ocean Palm Motel	Collins Avenue at 157th Street	$6.00 per day, room for 2 $8.00 per day, room for 2
Gregory Motel	16050 Collins Avenue	Two per room, $2.50 per person $6.00 per day for 2 in apartment
Windward Motel	16051 Collins Avenue	$6.00–$10.00 per day per room $2.00 per day extra over 2
Sea Breeze Motel	16151 Collins Avenue	$6.00–$12.00 per day per person
Sandy Shores Motel	16251 Collins Avenue	$5.00–$9.00 per day room for 2

The date of the meeting falls within the normal winter season, and it is urgently requested that reservations be in as far in advance as possible in order to assure adequate space and utmost efficiency. The meeting rates will apply only for a 6-day period. Prevailing rates will be charged for those days in excess of six. Rates for additional stay will be quoted by the hotel with confirmation. Although not mandatory, it is suggested that a deposit of at least one day's rent accompany reservation request. Such deposits will be refunded if reservation is cancelled 24 hours in advance of planned arrival. All reservations should be in by April 1, 1951.

REGISTRATION FEES

Members of the Southern District and adjacent territory should register in advance by filling in the advance registration card sent with the mailed announcement. Registration fees are $2.00 for members and $3.00 for nonmembers. Enrolled Students and families of members, no fee.

trips will be available for purchase upon registration, but planned attendance should be noted on return card so that adequate facilities will be available.

Registration booth for the meeting will open at 6:00 P. M. Tuesday, April 10, at the headquarters hotel, and remain open until 10:00 P. M., and again on Wednesday from 8:00 A. M. to 12:00 noon. Arrangements will be made to handle later registration at times to be announced.

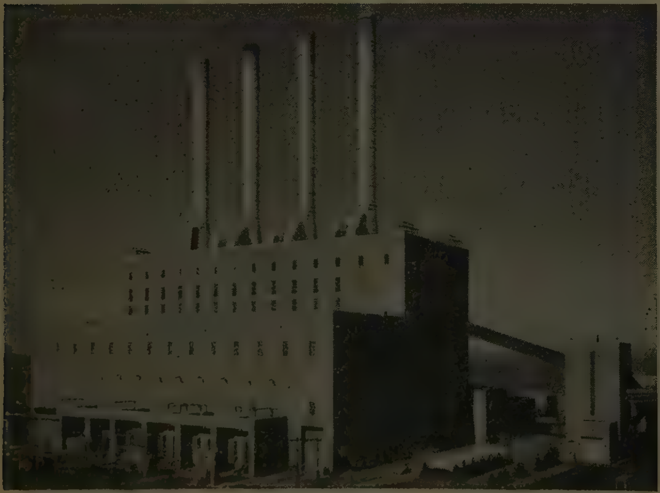
COMMITTEE MEMBERS

The members of the 1951 Southern District Meeting Committee are: Harvey F. Pierce, *Chairman;* J. W. Lacy, Jr., *Programs;* C. H. Summers, *Technical Program;* Dr. H. H. Sheldon, *Technical Papers;* E. F. Johnson, *Finances;* Clyde V. Booth, *Treasurer;* C. K. Lingo, *Publicity;* Ollie T. Ayers, Jr., *Hotels and Reservations;* W. C. Cogburn, *Sports and Entertainment;* Mrs. Ollie T. Ayers, Jr., *Ladies' Entertainment;* J. W. Beville, Jr., *Transportation and Inspection Trips;* and Frank Lucas, *Student Branch Co-ordinator.*

North Eastern District Meeting Features Electric Energy Papers

The AIEE North Eastern District Meeting will be held at Syracuse, N. Y., May 2–4. Meeting headquarters will be the Syracuse Hotel.

Because of rapid expansion in the electric load, the technical program features generation, application, and control of electric energy. The Power Generation Session on May 3 will emphasize the design features and the first published operating data of the reheat machines in the new Dunkirk Steam Station of the Niagara Mohawk Power Corporation. Electronics Park, the electronics center of the General Electric
Company, will be used for the electron
and communications session. Transpor
tion from the Syracuse Hotel to Electron
Park will be provided for those attendi
this session; luncheon facilities will be ava
able at 1:30 p.m. for those attending t
session. Syracuse is the home of the Carr
Air Conditioning Corporation. Problems
the manufacturers and utilities with t
increased usage of residential and commerc
air-conditioning equipment will be examin
at the Thursday afternoon session. T
assignment and development of the engine
as a professional man will be discussed
authorities at the Wednesday afterno
round-table presentation.



The Oswego Steam Electric Station at Oswego, N. Y.

The May 4 technical sessions have be
assigned to the Student Branches. T
Student Papers, both Graduate and Und
graduate, are worthy of full support fr
the older members of the Institute and
other sessions are scheduled for this da
Student Chairmen and Student Bran
Counselors will hold their annual lunche
after these sessions.

A trip through the Onondaga Potte
Company's Plant highlights an interesti
and entertaining program for the ladies.

The District Executive Committee w
hold their spring meeting starting with dinn
at 6:30 p.m., Tuesday, May 1.

Information concerning all features of t
meeting may be obtained at the Registrati
Desk. A complete schedule of all activit
and time and points of departure for
meetings and inspection trips will be carri
on the bulletin board near the Registrati
Desk. Please consult it frequently.

INSPECTION TRIPS

Several of the planned inspection tri
have been cancelled because of Federal
State security regulations and those schedul
are subject to change. It is suggested th
evidence of United States citizenship be ca
ried in the event of a change in these reg
lations. A nominal fee for transportati
will be charged and all those participating
these trips are requested to register and u
the transportation facilities as arranged
the committee in charge.

Syracuse University: During the past f
years the Engineering School of Syracu
University has moved into new mode
quarters, with complete laboratory equ
ment and facilities. An inspection t
has been arranged for Friday afternoo
which will include a complete tour of t
laboratories and facilities.

Electronics Park: On Thursday a
Friday afternoons trips have been schedu
to visit the modern facilities of the Electron
Park Plant of the General Electric Co
pany. In particular, a tour through t
metal-backed picture tube plant will be
feature of the visit. Movies of plant facilit
will be shown where security measu
prohibit inspection trips.

REGISTRATION FEES

Members and nonmembers should regis
in advance by filling in the advance regist
tion card sent with the mailed announ
ment. A registration fee of $2.00
members and $3.00 for nonmembers will
required upon arrival at the meeti
Enrolled Students and families of memb
will not be required to pay any fee.

Tentative Technical Program

North Eastern District Meeting, Syracuse, May 2–4

Wednesday, May 2

:00 a.m. Registration

:45 a.m. Symposium on Street Lighting

W. Bigley, presiding

P.** **A Utility and Street Lighting.** *D. A. Gaffney*, agara Mohawk Power Corporation

P.** **A Wire Manufacturer and Street Lighting.** *C. Graham*, Rome Cable Corporation

P.** **A Fixture Manufacturer and Street Lighting.** *M. Bjontegard*, General Electric Company

:45 a.m. Computing Devices

J. Maginniss, presiding

P.** **Transient Analyzer Applications.** *I. B. hnson*, General Electric Company

P.** **The Oarac—General Electric Company's ffice of Air Research Automatic Computer.** *Charles ayne*, General Electric Company

P.** **Guided Missile Calculation Using the ifferential Analyzer.** *E. G. Keller*, General Electric ompany

P.** **Critical Mass Calculations for Nuclear eactors.** *I. Bornstein, R. Habermann, F. J. Maginniss*, eneral Electric Company

:00 p.m. Round-Table Presentation

F. O'Neill, presiding

he Assignment and Development of the Engineer a Professional Man

J. L. Haley, Vice-President, Niagara Mohawk Power Corporation
M. M. Boring, Manager, General Electric Company's Technical Personnel Division
L. A. Russ, Director of Management Development, Westinghouse Electric Corporation
Dr. Chester L. Dawes, Harvard University
N. L. Freeman, Secretary, Engineering Board of Examiners, State of New York

hursday, May 3

:30 a.m. Power Generation

N. Ewart, presiding

P.** **Design Features and Initial Operating xperience of the Dunkirk Steam Station.** *R. P. oore*, Niagara Mohawk Power Corporation

P.** **Electrical Features of the Dunkirk Steam Station.** *J. M. Geiger*, Niagara Mohawk Power Corporation

DP.** **The 4th 80,000-Kw Unit at the Oswego Steam Station.** *Ben Green*, Niagara Mohawk Power Corporation

10:00 a.m. Electronics and Communications

E. W. Kenefake, presiding

50-234. **Local Wire Video Television Networks.** *C. N. Nebel*, Bell Telephone Laboratories Inc.

51-153. **A New Carrier-Current Frequency-Shift System for Use With Differential Protection of Transformer Banks.** *R. W. Beckwith*, General Electric Company

DP.** **Remote Control by Tones.** *J. L. Hayden*, General Electric Company

DP.** **Factors in the Choice of Microwave or Carrier Current for Power System Operation and Dispatching.** *F. C. Krings*, General Electric Company

2:30 p.m. Electronics and Communications

Inspection Trip of Electronics Park for those attending Electronics and Communications Sessions

2:30 p.m. Power Generation

J. N. Ewart, presiding

51-154. **The Use of Preferred Orientation Strip Steel in Turbine-Generator Stators.** *J. W. Apperson, C. B. Fontaine*, General Electric Company

51-155—ACO.* **The Effect of Unit Size on Steam Generating Station Design.** *A. G. Mellor*, General Electric Company

51-156. **System Economics of Extra-High-Voltage Transmission.** *H. P. St. Clair, E. L. Peterson*, American Gas and Electric Service Corporation

2:30 p.m. Air Conditioning

S. C. Osborne, presiding

Panel Presentation and Discussion on The Problems of Power Supply for Packaged Air-Conditioning Equipment

DP.** **Utilities' Viewpoint.** *J. W. Anderson*, Philadelphia Electric Company

DP.** **Motor Manufacturers' Viewpoint.** *C. P. Potter*, Wagner Electric Corporation

DP.** **Air-Conditioning Manufacturers' Viewpoint.** *W. L. McGrath*, Carrier Corporation

Friday, May 4

9:30 a.m. Undergraduate Student Branch Papers

H. F. Cooke, presiding

9:30 a.m. Graduate Student Branch Papers

L. E. Lingo, presiding

—PAMPHLET reproductions of authors' manuscripts of the numbered papers listed in the program may be obtained from AIEE Order Department, 33 West 39th Street, New York 18, N. Y., as noted in the following paragraphs.

—PRICES for papers, irrespective of length, are 30 cents to members (60 cents to nonmembers) whether ordered by mail or purchased at the meeting. Mail orders are advisable, particularly from out-of-town members, as an adequate supply of each paper at the meeting cannot be assured. Only numbered papers are available in pamphlet form.

—COUPON books in nine-dollar denominations are available for those who may wish this convenient form of remittance.

—THE PAPERS regularly approved by the Technical Program Committee ultimately will be published in Proceedings and Transactions; also, each is scheduled to be published in Electrical Engineering in digest or other form.

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* **ACO:** Advance copies only available; not intended for publication in *Transactions*.

** **DP:** District paper; no advance copies are available; not intended for publication in *Transactions*.

HOTEL ACCOMMODATIONS

Arrangements have been made to provide nple room accommodations for those embers attending from outside of Syracuse nd vicinity. Room reservation cards will forwarded with the mailed announcement. oom rates at the Hotel Syracuse are:

ngle Room	$4.75, 5.25, 5.75, 6.25, 7.75
ouble Room	$6.75, 7.75
win-Bedded Room	$7.25, 8.25, 9.75
rlor Suites—Parlor, Bedroom, and Bath	$14.50 to $25.00

ENTERTAINMENT

A stag smoker, with novel and interesting ntertainment, will be held Wednesday vening, May 2, while the ladies enjoy dinner Tobins.

Mr. A. C. Monteith, Vice-President of Westinghouse Electric Corporation, will speak on "Engineering, Its Future" at the mixed banquet on Thursday evening, May 3. A social hour will precede the banquet. All social functions will be informal.

LADIES' PROGRAM

The ladies visiting the meeting will be provided with an entertaining and interesting program. The schedule of activities is:

Wednesday, May 2

A.M.	Registration
12:30 P.M.	Luncheon and social hour at the Syracuse Hotel
2:30 P.M.	Mary Aldrich Jones will review a recent New York play
6:30 P.M.	Dinner at Tobins, a popular Syracuse restaurant

Thursday, May 3

10:00 A.M.	Transportation will be provided to the Onondaga Pottery Company's plant, where the world-famous Syracuse China is made
1:00 P.M.	Luncheon and bridge at the Bellevue Country Club
6:00 P.M.	Ladies are invited to the social hour and banquet at the Syracuse Hotel. Dress is informal

Friday, May 4

A.M.	No formal program is planned. Shopping tours and visits to

points of interest will be arranged upon request for the visiting ladies

NORTH EASTERN DISTRICT COMMITTEE

Committee members are: J. D. Hershey, *General Chairman;* J. H. McClennan, *Finance;* M. H. Pratt, *Technical Program;* George Pring, *Publicity;* H. F. Cooke, *Student;* Dave Williams, *Hotels;* C. E. H. Von Sothen, *Registration;* Paul O'Neill, *Entertainment;* L. M. Moore, *Trips and Transportation;* B. T. Cole, *Social Hour;* and Mrs. Paul O'Neill, *Ladies' Program.*

Great Lakes District Meeting Will Be Held in Madison, Wis., May 17–19

A technical program having a wide appeal is being formulated for the American Institute of Electrical Engineers' Great Lakes District Meeting, which will be held in Madison, Wis., May 17–19, 1951. Headquarters for the meeting will be the Loraine Hotel.

TECHNICAL PROGRAM

The program, arranged by Professor T. J. Higgins, will consist of a general session on Thursday morning, followed by technical sessions on Thursday afternoon and Friday. The following session titles show the wide variety of subjects covered by the papers to be presented: Power Transmission and Distribution; A-C Machinery; Unique Features in Central Stations; Basic Sciences; Communication Circuit Analysis; Instruments and Measurements; Industrial Electronics; Servomechanisms; Feedback Control Devices; Unique Field Mapping Procedures; Analogue Computing Techniques and Devices; and Waveguides and Particle Accelerators.

A symposium on the Theory and Application of Nonlinear Electric Circuit Analysis has been scheduled. This session will be of prime interest to teachers, graduate students, and those in industry who are working on nonlinear servomechanism problems and related work. Those presenting papers at the symposium are Dr. Ernest Keller of the General Electric Company, Dr. Richard Duffin of the Carnegie Institute of Technology, Dr. Frank Bothwell of Northwestern University, and Dr. Hans Schaffner of the University of Illinois.

STUDENT ACTIVITIES

Every effort is being made by the committees to include students in all activities. There will be no separately scheduled student meeting on Thursday, which will permit students a full day to become acquainted with the practicing engineers. Friday there will be undergraduate and graduate paper sessions. Prizes will be awarded. On Saturday morning Student Branch chairmen and Branch counselors will have a business meeting followed by a noon lunch. Students will be welcome on all inspection trips and the students' wives are invited to attend the ladies' program.

INSPECTION TRIPS

Inspection trips will include the new Electrical Engineering and Mechanics Building on the University of Wisconsin campus, which will be dedicated only two weeks prior to the meeting. The building is now occupied and laboratory equipment completely installed. There are many laboratories covering other fields at the University of Wisconsin which may be of special interest to some. Arrangements can be made for individuals to visit other buildings on the campus.

An inspection trip also is scheduled for the Forest Products Laboratory, a Department of Agriculture laboratory doing continual research on the use of forest products including the use of wood for structural purposes. A great deal of work has been done in the past on pole strengths, lives, and so forth, at this laboratory.

The Veterans Administration will be completing a new hospital at the time of the meeting and those attending will have an opportunity to see the most modern methods of distributing electricity and connecting utilization equipment in a modern building.

Inspection trips to utility properties are being arranged to cover unique features of various installations.

SOCIAL ACTIVITIES

Two luncheons at the headquarters hotel and a banquet at the Memorial Union at the University of Wisconsin are scheduled. All members, students, and ladies invited to attend the luncheons and banqu A special program is being arranged for ladies.

During the Great Lakes District Meeting there will be an opportunity to see the new Electrical Engineering and Mechanics Building at the University of Wisconsin. This building is complete and occupied and will be open for inspection at the meeting

HOTEL RESERVATIONS

E. J. Kallevang, chief engineer, Wiscon Power and Light Company, 122 W Washington Avenue, Madison 1, W again urges those who will attend meeting to make hotel reservations ea He suggests that if you make your reser tions directly you send a copy of the le to him. Or if you wish, you can have Kallevang make the reservation for you.

Room rate schedules for four hotels Madison are:

Loraine Hotel (headquarters for meetin
123 W. Washington Avenue

Single rooms.............	$ 4.00 to $ 6
Double rooms............	8.00 to 10

Edgewater Hotel, 666 Wisconsin Avenu

Single rooms.............	6.00 to 8
Double rooms............	10.00
Twin....................	12.00

Park Hotel, 22 South Carroll Street

Single rooms.............	3.50 to 5
Double rooms............	5.00 to 9

Piper's Belmont Hotel, 31 North Pinck
Street

Single rooms.............	3.50 to 5
Double rooms............	5.00 to 8

Accommodations at motor courts are av able. Early reservations are necessa Rates at motor courts are approximat $4.00 for single and $5.50 for double cupancy. Three motor courts which close to Madison are:

Hamacher Motel (On State Trunk Highw 12, 13, and 14), 5101 University Aven Madison, Wis.

Mid-View Apartment Motel (State Tr Highway 12 and 13), Middleton, Wis.

Blue Spruce Motel (On State Tr Highway 12 and 18), 1901 E. Broadw Madison, Wis.

D. I. Bohn is Named Recipient of the Lamme Medal for 1950

Donald Ivan Bohn, Chief Electr Engineer of the Aluminum Company America, was selected by the AIEE Lam Medal Committee, at its meeting on Janu 24, 1951, to receive the 1950 Lamme Me The award is being made to Mr. Bohn his pioneering development and applica of electrical equipment for control rectifying systems in the production aluminum."

The Lamme Medal is awarded annua under bequest of Benjamin G. Lamme, member of the AIEE "who has sh meritorious achievement in the developm of electrical apparatus or machinery." award will be made during the A Summer General Meeting in Toro Canada.

A brief biographical sketch of Mr. B will be found in the AIEE Personal column, page 365.

IEE Board of Directors Holds Regular Meeting in New York

The regular meeting of the Board of irectors of the American Institute of ectrical Engineers was held at Institute eadquarters, New York, N. Y., on January , 1951, during the Winter General Meet-g of the Institute.

The minutes of the meeting of the Board Directors held on October 26, 1950, were proved.

The following actions of the Executive mmittee on membership applications, on recommendation of the Board of aminers, were reported and confirmed: of November 24, 1950—1 applicant cted to the grade of Fellow, 19 applicants cted to the grade of Member, 1 Member -elected, 58 applicants elected to the grade Associate, 8 Associates re-elected, and 274 Student members enrolled; as of ecember 28, 1950—26 applicants trans-rred and 1 elected to the grade of Fellow, applicants transferred, 21 elected, and 2 -elected to the grade of Member, 135 plicants elected and 12 re-elected to the ade of Associate, and 785 Student members rolled.

Recommendations adopted by the Board Examiners at meetings on November 16 d December 21, 1950, and January 18, 51, were reported and approved; and the lowing actions were taken upon recom-endation of the Board of Examiners: 17 plicants were transferred to the grade of llow, 66 applicants were transferred, 27 cted, and 2 re-elected to the grade of ember, 187 applicants were elected and 10 -elected to the grade of Associate, and 243 udent members were enrolled.

FINANCES

Expenditures were reported by Chairman . J. Barrett of the Finance Committee, d approved by the Board, as follows: vember 1950, $74,818.05; December 50, $53,801.03; January 1951, $66,824.18.

A statement of income and expenses for e elapsed portion of the present appro-iation year, compared with the figures the same period of last year, was pre-nted, indicating a situation this year not out of line with that of last year.

Upon recommendation of the Finance mmittee, a resolution was adopted "to p from membership any person owing es for the fiscal year which began May 1, 49, with the understanding that the pended member may become reinstated hout the formality of an application for nstatement if dues in arrears are paid or to May 1, 1951."

Continuing a policy that has been in ce for several years, a resolution proposed the Finance Committee was adopted, follows: "That the Secretary be au-rized to accept, during the fiscal year ginning May 1, 1951, payment of member-p dues on the basis of the par currency ue of countries affected by abnormal hange rates—the member concerned to granted an exchange allowance corre-nding to the difference between the New k exchange value and the normal par his currency, such allowance not to exceed 40 per cent of the dues payable and not to apply to purchases of or subscriptions to Institute publications; a corresponding reduction in appropriation payments to be applicable to Institute Sections in any countries affected."

RESOLUTIONS AND RECOMMENDATIONS

As required by Section 25 of the Bylaws, the Board adopted a resolution that the 1951 Annual Meeting of the Institute be held in Toronto, Ontario, Canada on Monday, June 25.

The Board approved recommendations of the Edison Medal Committee for revisions of the committee's bylaws by the deletion of the provisions for ex-officio members (President, Secretary, and Treasurer of AIEE), to conform to the Board's recent elimination of ex-officio committee memberships.

Approval was given to the addition to the bylaws of the Lamme Medal Committee of a statement of interpretation of Mr. Lamme's words "electrical apparatus or machinery," which had been approved by three Lamme Medal Committees and by the Board of Directors. (The statement appears on page 653 of the July 1950 *Electrical Engineering*.) Other revisions of the committee's bylaws were approved, to remove the word "National" preceding the word "Secretary."

The following actions were taken upon request of the members involved, approval of the Section and District officers concerned, and recommendation of the Sections Committee:

Granted Section status to the Albuquerque Subsection of the New Mexico-West Texas Section, with the name of Northern New Mexico Section, and with territory comprised of the following counties in the State of New Mexico, transferred from the New Mexico-West Texas Section, effective immediately: San Juan, Rio Arriba, Taos, McKinley, Sandoval, Santa Fe, San Miguel, Valencia, Torrance, Mora, Guadalupe, Bernalillo, DeBaca, and Los Alamos.

Authorized the transfer of the Shreveport Section territory from the Southern District (Number 4) to the South West District (Number 7), effective August 1, 1951. (The territory of the Shreveport Section remains unchanged.)

Authorized the transfer of the territory of the Lake Charles Subsection from the New Orleans Section and District 4 to the Beaumont Section and District 7, effective August 1, 1951.

Authorized the transfer of Kay County, Okla., from the territory of the Oklahoma City Section to that of the Tulsa Section, effective immediately.

Chairman C. G. Veinott of the Special Committee to Study Plan for Recognition of Section Growth submitted the report of the committee, which was appointed by the Board of Directors in August 1950 to study the Section Growth Plan instituted in District 2 and to make recommendations to the Board regarding the desirability of the adoption of a similar plan for application to all AIEE Sections. The committee's report described the development of the growth formula and outlined rules to govern Section growth award. The Board accepted the report of the special committee and assigned the administration of the plan to a special Subcommittee on Section Growth Award of the Sections Committee.

STUDENT BRANCH ACTIVITIES

Chairman McMillan of the Committee on Student Branches reported approval by that committee of the establishment of a Student Branch of the Institute at the University of Massachusetts, which was authorized by the Board of Directors in October, subject to such approval by the committee. The Branch has since become organized.

Upon recommendation of the Committee on Student Branches, the Board authorized the organization of AIEE Student Branches at the University of Toledo, Toledo, Ohio, and the United States Naval Academy, Annapolis, Md.

In accordance with recommendations of the Joint AIEE-Institute of Radio Engineers (IRE) Coordination Committee and the Committee on Student Branches, the Board approved the establishment of a continuing joint subcommittee under the Education Committee of IRE and the Committee on Student Branches of AIEE for the purpose of resolving "differences of Joint Student Branches, which are of such magnitude or of such specialized nature that they cannot be settled by the Executive Secretary of the IRE and the Secretary of the AIEE."

The Board adopted a recommendation of the Committee on Student Branches that the policy followed in connection with World War II, of suspended membership for Student members in the armed services, be applied in the present national emergency, effective with the next fiscal year, beginning May 1, 1951. A question of similar action covering corporate members of the Institute was referred to the Committee on Planning and Coordination for review of actions during World War II and recommendation to the Board.

The Board approved a procedure for an annual award to a Student in each Branch for outstanding activity within the Branch, recommended by the Committee on Student Branches.

AMENDMENTS AND OTHER BUSINESS

The Board approved, for submission to the membership for vote, amendments to the Constitution recommended by the Committee on Constitution and Bylaws in accordance with previous Board approval of the changes in principle, to effect the transfer of the provisions for entrance and transfer fees and dues from the Constitution to the Bylaws, to limit the procedure for transfer to the Fellow grade to invitation by the Board of Directors upon recommendation by five Fellows or Members, and to establish grades of membership more in line with those recommended by the Engineers' Council for Professional Development for adoption by its constituent societies—the last mentioned involving the creation of a new grade, that of Affiliate, and a change in name of the Associate grade to Associate

Attending the AIEE Board of Directors meeting in New York were: left to right, bottom row—A. C. Monteith, Elgin B. Robertson, Victor Siegfried, W. L. Everitt, and C. S. Purnell. Center row—E. W. Davis, W. I. Slichter, J. F. Fairman, President T. G. LeClair, F. O. McMillan, W. J. Seeley, and W. J. Barrett. Top row—A. G. Dewars, J. A. McDonald, R. A. Hopkins, J. R. North, C. W. Fick, A. H. Frampton, H. J. Scholz, J. G. Tarboux, H. R. Fritz, H. H. Henline, and N. B. Hinson

Member grade, with certain changes in the requirements for the grades of Associate Member and Member. Corresponding changes in the Bylaws were adopted, contingent upon adoption of proposed constitutional amendments by the membership.

In accordance with the policy adopted by the Board of Directors of eliminating ex-officio committee membership, the first paragraph of Section 83 of the Bylaws was amended to read: "The Standards Committee shall consist of fifteen or more appointed members, including at least one member of the Board of Directors."

Chairman M. D. Hooven of the Committee on Planning and Coordination reported a summary of replies from the technical division advisors to an inquiry by President LeClair for their opinions as to the spacing of the general meetings, particularly regarding a suggestion that the Winter General Meeting be held in February, about a month later than the usual time. The replies from the advisors comprised about an equal number of arguments for both sides of the question of having the meeting in February instead of January, and a survey of the hotel situation in New York indicated that the present dates are the best so far as hotel accommodations are concerned. The Committee on Planning and Coordination concluded that it would be best to continue holding the meeting in January until such time as it is requested for some other city, when the suggestion for holding it later should be reconsidered.

Tentative plans for participation of various societies in the Centennial of Engineering, Chicago, 1952, were reported, including proposed AIEE technical conferences on the dates September 10–12, plans for which are being made by the chairmen of the Technical Advisory and the Technical Program Committees. Upon recommendation of the Committee on Planning and Coordination, the Board confirmed the dates of September 10–12, and approved the title "AIEE Participation in the Centennial of Engineering."

Upon recommendation of the Committee on Planning and Coordination, following consideration of a question raised by Chairman Willis of the Technical Program Committee, the Board voted to waive the meeting registration fee in the case of invited nonmember authors, and to request the Technical Program Committee to develop a suitable program.

A new technical committee was authorized, namely, Committee on Magnetic Amplifiers, in the Science and Electronics Division, upon recommendation of the Technical Advisory Committee and the Committee on Planning and Coordination.

Director A. C. Monteith, one of the Institute's three representatives on the Engineering Manpower Commission of Engineers Joint Council (EJC), reported on activities of the Commission and outlined the plans to attain its purpose, which is "to develop policies and procedures designed to secure the most effective use of engineering skills and experience in industry and in government, both civilian and military, during the emergency; to take the necessary steps within the scope of Engineers Joint Council to put such policies and procedures into practice." EJC has approved the program and authorized the solicitation of the necessary funds from industry and others, including the EJC participating societies. The Board of Directors voted to appropriate the Institute's share of the contribution requested of the EJC participating societies.

AIEE APPOINTMENTS

A report on the work of the EJC Panel on a National Water Policy was received. The Board confirmed the reappointment by the President of C. W. Mayott as the AIEE representative on the EJC Panel on a National Water Policy for the duration of its activity.

In accordance with the established pr
cedure, report was made of the reappoi
ment by the Committee on Electronics
W. G. Dow as AIEE representative on t
Board of Directors of the National El
tronics Conference, and the Board approv
the reappointment.

W. J. Barrett was appointed an AII
representative on the Joint AIEE-IR
Coordination Committee for the 2-ye
term beginning February 1, 1951.

Report was made of the presentation
AIEE of a scroll to the National Bureau
Standards on the occasion of its 50th an
versary celebration. The scroll was pr
sented by President LeClair during t
Joint Conference on High Frequen
Measurements held in Washington, D. C
January 10–12, 1951. See story in t
March issue (*EE, Mar '51, pp 263–64*).

It was reported that, following nominati
by the AIEE Board of Directors, Pa
President R. W. Sorensen has been elect
an Honorary Member of The Institute
Electrical Engineers of Japan.

The President was authorized to appoi
an AIEE delegate to the 75th anniversa
celebration of the American Chemic
Society, September 3–7, 1951, and to appoi
two delegates to the Joint Engineeri
Conference to be held in London, June 4–1
1951, which is being organized by t
Institutions of Civil, Mechanical, a
Electrical Engineers.

The President was empowered to atten
or to select some one else to attend, a meeti
to be held in Havana, April 19–22, 195
of the Union of Pan American Engineeri
Associations (UPADI), as the AIEE repr
sentative on a delegation of Engineers Joi
Council.

It was decided, upon invitation of t
Portland Section and the 1951 Paci
General Meeting Committee, to hold t
August 1951 meeting of the Board of Dire
tors in Portland, Oreg., during the Paci
General Meeting, August 20–23.

Various other matters were discusse
including the December 1950 report of t
Exploratory Group to Consider Furth
Unity in the Engineering Profession (und
auspices of the Engineers Joint Council).

Present at the meeting were: *President*
G. LeClair; *Past President* J. F. Fairma
Vice-Presidents A. H. Frampton, H.
Fritz, R. A. Hopkins, J. A. McDonald, J.
North, C. S. Purnell, W. J. Seeley, J.
Tarboux, C. G. Veinott; *Directors* W.
Barrett, E. W. Davis, A. G. Dewars, W.
Everitt, C. W. Fick, N. B. Hinson, M.
Hooven, F. O. McMillan, A. C. Monteit
Elgin B. Robertson, H. J. Scholz, Vict
Siegfried; *Treasurer* W. I. Slichter; *Secreta*
H. H. Henline.

Summer General Meeting to Feature Variety of Events

The various programs being arranged f
the visitors to the 1951 AIEE Summ
General Meeting in Toronto, Canada, Ju
25–29, indicate that the activities, technic
as well as social, have been chosen to inclu
items of particular interest to all. T
Technical Program Committee has plann
a group of technical papers covering
phases of electrical engineering, with e
phasis on subjects in the power field.

Thirty-five technical sessions and con- ences are being planned by the following chnical committees of the Institute: ransmission and Distribution, Relays, Elec- onic Power Converters, Land Transporta- on, Basic Sciences, Power Generation, struments and Measurements, Safety, troleum Industry, Feedback Control Sys- ms, Insulated Conductors, Carrier Current, ucleonics, Wire Communication Systems, omputing Devices, Protective Devices, dustrial Power Systems, Switchgear, ransformers, Electronics, Mining and Metal dustry, Industrial Control, Metallic Recti- ers, and System Engineering.

INSPECTION TRIPS

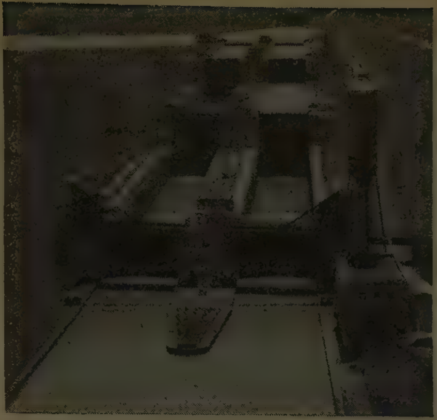
In the arrangements for the various spection trips, the committee again has ndeavoured to achieve as much variety as ossible. Canada's first subway, being nstructed at the present time in Toronto, advanced to a stage that offers much to terest the engineer. A tour of this project as been arranged, as well as a visit to the illcrest Maintenance shops of the munici- ally owned Toronto Transportation Com- ission. These shops are considered to be mong the finest on the continent and are ecognized by maintenance engineers for e efficient despatch with which electrical aintenance and repairs are effected on oronto's 1,100 transportation units. Visi- rs to Toronto, home of nearly 1,000,000 eople, will find not only beautiful residential istricts but also great industrial areas of odern factories. The large plants that ill be visited include the Canadian General lectric, Ferranti Electric, Sangamo Elec- ic, Rogers Majestic, and the Frigidaire ompany, all located in Toronto. The teel Company of Canada and the Canadian Vestinghouse plants will be visited during trip to Hamilton, an hour's drive west of oronto on the modern Queen Elizabeth ighway.

In the communications field, an inspection ip to The Bell Telephone Company's Toll entre in Toronto will afford visitors an pportunity to see the largest toll switch- oard installation in Canada, together with odern toll terminal equipment including carrier terminals for 600 telephone rcuits. A trip to Oshawa and Cannington, short distance east of Toronto, will permit e inspection of the modern *K* and *J* carrier peater stations of this company.

An evening visit has been planned to the unlap Observatory, located on the northern utskirts of the city. This trip should prove qually interesting to the ladies.

LADIES' PROGRAM

The committee responsible for planning e ladies' entertainment has arranged a umber of interesting functions. In this rogram are included a sight-seeing tour of e city during which lunch will be had at asa Loma, Toronto's Castle on the Hill, d an interesting exhibition and tea ar- nged by the T. Eaton Company, featuring display of items purchased in every corner the world and brought together for sale the stores of this great company in oronto and across Canada. Hart House, e magnificent student recreational build- g of Gothic architecture at the University Toronto, will be the setting for an evening social entertainment. This will include a display in the swimming pool, a theatrical presentation, and dancing in the Great Hall.



Twin flight locks at Thorold on the Welland Canal will be visited during one of the inspection trips at the AIEE Summer General Meeting

An important function for all visitors will be the President's reception which will be held at the Royal York Hotel and will be followed by a buffet supper and an informal dance. The Royal York is the headquarters hotel.

RECREATION

Arrangements are being made for golf and tennis privileges to be available at various clubs for those visitors who wish to play, and during the week of the meeting the annual golf competition for the Mershon Trophy will be held.

RESERVATIONS

Members planning to attend the Summer General Meeting should make reservations with the Royal York Hotel, Front Street West, Toronto, Canada, without delay.

Royal York Hotel (Meeting Headquarters)	**Rates Per Person**
Single room	$ 6.50 to $ 8.00
Parlour-bedroom	9.50 to 10.00
Double room	$5.25 to $6.00
Parlour-bedroom	6.75 to 7.00
	Rates Per Suite
Suites—single occupancy—bedroom and sitting-room	16.00 to 26.00
Suites—double occupancy—bedroom and sitting-room	20.00 to 31.00

King Edward Hotel	
Single room, bath (1 person)	5.00 to 6.50
Double room, double bed, bath (2 persons)	8.50 to 10.00
Double room, twin beds, bath (2 persons)	9.00 to 10.00
Two connecting rooms (3 persons)	13.50 to 16.50
Two-room suites—single occupancy	12.00 to 15.00
Two-room suites—double occupancy	15.00 to 18.00
Three-room suites—single occupancy	18.00 to 36.00
Three-room suites—double occupancy	24.00 to 36.00

District 4 Student Convention to Be Held Week of April 9

The University of Florida AIEE-Institute of Radio Engineers Joint Student Branch will act as host at the Student AIEE Southern District Convention meeting in Florida. Delegates from the different schools will have the opportunity to see Florida, spend a few days at Miami Beach, and hear some good student papers. In addition to this, students will go on inspection tours and trips with the senior group, which will meet at the same time. (See story on Southern District Meeting on pages 354–56.)

All students should register at the University of Florida in Gainesville, where a dinner, inspection trips, and entertainment will be provided on Monday, April 9. April 10 will be spent traveling to Miami, stopping to see a number of top tourist attractions throughout the state.

The 11th, 12th, and 13th will be spent in Miami Beach. The Student Branch Meeting technical sessions will be held April 11 and 12 at the MacFadden-Deauville Hotel, headquarters of the AIEE Southern District Meeting. The students will be quartered at the Northshore Hotel. Locker and swimming privileges will be extended at the Northshore, as well as at the MacFadden-Deauville. Arrangements have been

Fall Meeting to Have Laboratory Trip

A research team is recording data in the control room during the operation of the world's largest supersonic wind tunnel at the National Advisory Council for Aeronautics Lewis Flight Propulsion Laboratory, Cleveland, Ohio. This laboratory is one of the inspection trips scheduled for the AIEE 1951 Fall General Meeting, to be held in Cleveland, Ohio, October 22–26

The Engineering and Industrial Experiment Station is one unit of the newly dedicated Engineering and Industries Building at the University of Florida. This will be seen by those attending the Southern District Student Convention

made to allow students to remain over the week end, at special rates, if they should so desire.

It is important that students register at the University of Florida to get their brief cases containing maps, folders, programs, instructions on tourist attractions, and many other vital items connected with a good time at the convention.

Tentative Program for AIEE Textile Conference (North)

The AIEE Textile Industry Conference (North) will be held at the Engineers Club, Philadelphia, Pa., on April 23. It is sponsored jointly by the Textile Subcommittee, the AIEE Philadelphia Section, and the Philadelphia Textile Institute.

The proposed program for the Textile Conference follows.

Morning

Static Electricity

Principles of Static Electricity. *L. W. Walkup*, Battelle Memorial Institute

Static Electricity, A Cotton Textile Problem. Speaker from Institute of Textile Technology

Synthetic Textiles and the Static Problem. *Dr. M. Hayek*, E. I. DuPont Company

Static in the Woolen Industry. *L. A. Runton*, Director of Machinery Research, M. T. Stevens Company

Afternoon

Good Electrical Installation Practice

Fundamentals of Good Electrical Installation Practice. *Swaffield Cowan*, Factory Insurance Association

Wiring the Loom. *V. F. Sepavich*, Crompton and Knowles Loom Works

Electrical Installation on Full Fashioned Hosiery Machines. *L. Marburger*, Berkshire Hosiery Mills

Finishing Plant Electrical Installation Problems. *J. D. McConnell*, Cone Mills

Tentative Program for AIEE Textile Conference (South)

The AIEE Textile Industry Conferenc (South) will be held on April 26 and 27 the Georgia Institute of Technology Atlanta, Ga. This conference is sponsore jointly by the Textile Subcommittee, th AIEE Atlanta Section, and the Philadelphi Textile Institute.

The proposed program is as follows:

April 26

Morning

The Eddy Current Clutch. *K. H. Boehmer*, Louis All Company

The Card Drive Story. *R. E. Parker*, General Electr Company; *L. T. Jester*, General Electric Company

Afternoon

Principles of Static Electricity. *L. W. Walkup*, Battel Memorial Institute

Static Electricity, A Cotton Textile Problem. Speak from Institute of Textile Technology

Static in the Woolen Industry. *L. A. Runton*, Direct of Machinery Research, M. T. Stevens Company

Synthetic Textiles and the Static Problem. *Dr.* *Hayek*, E. I. DuPont Company

April 27

Morning

Design of a Textile Mill Power System. *R. B. Wic ham*, West Point Manufacturing Company

Considerations in Installation of a Mill Power Syste *J. C. Cummings*, Bryant Electric Company

Problems in Operation and Maintenance of a M Power System. *Dude Ray*, Avondale Mills

District 7 Student Convention Will Be Held April 23-24

The University of Texas Student Branc in Austin, Tex., will be host to the AIE South West (District 7) Student Conventic April 23–24, 1951.

Lehigh Valley Section Has Color Television Demonstration

Industrial color telev sion was demonstrated 230 members and gues of the AIEE Lehig Valley (Pa.) Section at dinner meeting in th Berkshire Hotel, Rea ing, Pa., February 9, b James J. Reeves of th Research and Develo ment Department Columbia Broadcastin System (CBS). Left right are: CBS camer man, J. A. Niedeck, J. Leslie, J. J. Reeves, O. Titus, D. A. Campbe Jr., H. R. Wilbur, man ger, Reading District, L. Price, W. H. Dora Mrs. Sonia Ketterer

On Monday, April 23, technical papers ll be presented in morning and afternoon ssions. There will be a luncheon at noon, d at 4:00 p.m. a Tea Dance will be ld in the Texas Union. That evening a Kappa Nu will give a banquet honoring e original petitioners for the Psi Chapter The University of Texas.

Tuesday morning will be devoted to the esentation of the remaining technical pers. In the afternoon an inspection trip ll be conducted through the Austin City wer Plant. The convention will conclude e evening of the 24th with a banquet ld with the South Texas Section of AIEE d the San Antonio Section of the Institute Radio Engineers, when the winner of the chnical paper contest will be announced.

udent Branch at Princeton Hears Talk on Ultraviolet Rays

The joint AIEE–Institute of Radio gineers student branch at Princeton Univsity was addressed by Walter H. Garrett and r. Erickson of the Commercial Engineering epartment, Lamp Division, Westinghouse ectric Corporation, on February 1. They esented an interesting discussion along th demonstrations of ultraviolet rays as ed in lighting, fluorescent, and mercury por lamps.

Mr. Garrett stated that ultraviolet has visible rays of its own. The lowest traviolet is in the region of 1,800 angstrom its and is called ozone. Ozone is used ainly in germicidal lamps where the ultraolet ray causes the germ to "blow up" and plode, thus killing it. Caution was essed in installing and using this lamp ce the ozone rays are injurious to the es, causing acute conjunctivitis. Their plication in schools has produced a -per cent reduction in minor throat and sal irritations. A 3,000-angstrom-unit avelength ray is used in sun lamps proicing vitamin D. The use of this type of mp is self-explanatory. Mr. Erickson monstrated the effects of the near visible "black light" at 3,650 angstrom units d explained its use in the inspection of stings, minerals such as petroleum, and citing fluorescent paints in darkened areas.

Mr. Garrett demonstrated the mercury c lamp. This lamp is the most efficient urce of light, giving 67 lumens per watt against 18 lumens per watt for the ordinary candescent lamp. By the use of glass ters, the harmful effects of the ultraviolet ay be eliminated while with a luminescent ade light may be produced.

A brief discussion of the requirements for sign of any lighting installation was given th the aid of pamphlets. The quantity light for an area may be calculated in o ways, the lumen method or the point-byint method. The second method is more curate but is employed only when relaely few direct-type luminaries are used.

ast Chairmen Honored at AIEE Michigan Section Meeting

Past Chairmen of the AIEE Michigan Section are: seated, left to right, J. J. Shoemaker, A. H. Lovell, E. L. Bailey, H. Cole, F. L. Snyder, G. E. Lewis, A. A. Meyer, and J. H. Cannon. Standing, left to right, are: M. R. Horne, E. F. Dissmeyer, M. M. Cory, D. H. Baker, J. R. North, O. E. Hauser, A. W. Rauth, M. B. Stout, G. M. Chute, E. V. Sayles, S. S. Attwood, L. W. Clark, H. P. Seelye, F. H. Riddle, W. Knickerbocker, and L. Braisted

The Michigan Section of the American stitute of Electrical Engineers observed 40th anniversary and honored the Past Chairmen at a meeting held January 16, 1951, at the Bell Building in Detroit, Mich.

The Past Chairmen of the Michigan Section were guests of the Institute at a dinner preceding the talk. Excerpts from the History of the Michigan Section of the Institute were read following the introduction of the Past Chairmen.

Dr. J. W. McRae, Director of Transmission Development of the Bell Telephone Laboratories, spoke on "Microwave Superhighways for Television and Telephony." He gave a technical description of the microwave system between New York and Chicago and an account of the research, development, and engineering effort involved in the transcontinental radio relay system now under construction. Total attendance at the meeting was more than 200.

Trevor Clark Speaks at Tampa Meeting. At a meeting of the Tampa Subsection of the Florida Section held on January 19, Trevor H. Clark gave a timely talk on uses of microwave radio in connection with television, transmission, and telephony. He also showed slides and a 20-minute film displaying various installations of microwave units.

Mr. Clark is in charge of engineering services for the Federal Telecommunication Laboratories, Inc. He was awarded the United States Navy Certificate of Commendation for his work in the research and development of certain direction finders for the Armed Forces.

COMMITTEE ACTIVITIES

Editor's Note: This department has been created for the convenience of the various AIEE technical committees and will include brief news reports of committee activities. Items for this department, which should be as short as possible, should be forwarded to R. S. Gardner at AIEE Headquarters, 33 West 39th Street, New York 18, N. Y.

Communication Division

Committee on Radio Communications Systems. (*G. T. Ryoden, Chairman; E. D. Becken, Vice-Chairman; A. C. Dickieson, Secretary.*) At a committee meeting on January 25, 1951, discussion of possible papers for future meetings indicated that this committee could sponsor one session at the Fall General Meeting in Cleveland. Mr. Dickieson, as Chairman of the Subcommittee on Mobile Radio, submitted a comprehensive report on the work done during the past year on the protection of fixed radio stations, intended for mobile service, against damage by lightning. The committee considered that the report was excellent and decided that copies should be made available to all members of the Subcommittee on Mobile Radio and others who have indicated their interest in the subject with a request for comments.

General Applications Division

Committee on Domestic and Commercial Applications. (*C. F. Scott, Chairman; T. H. Cline, Vice-Chairman; J. P. Harris, Secretary.*) This committee is planning a technical conference to be held on May 15 at the Battelle Memorial Institute in Columbus, Ohio. This conference will be sponsored by the Subcommittee on Domestic Appliances, and will be devoted to engineering and research phases of appliance applications. Co-operating in the conference is the Columbus Section. Further details will be announced later.

The committee has noted the widespread interest in Electric Space Heating and Heat Pumps, evidenced by the attendance and discussion at the session on these topics during the Winter General Meeting, which was the fourth such session in recent years. Certain problems stand out as challenging ones, and the attention of readers of *Electrical Engineering* is invited to the opportunity of contributing toward their solution. For example, the problems of heat storage and of peak limiting devices are significant if there is to be widespread use of electric power for space heating, and really satisfactory solutions are of interest to both public utility men and home builders.

Industry Division

Committee on Feedback Control Systems. (*S. W. Herwald, Chairman; F. E. Crever, Vice-Chairman; A. G. Kegel, Secretary.*) In order to permit full discussion of the state of the art in its applications to many fields, a Conference on Feedback Control Systems will be held in the autumn of 1951. The sessions should prove of interest to people in a wide variety of industries, such as machine tools, aviation, chemical processes, combustion, utilities, steel, paper, and many others. Plans are being made for a 2- or 3-day conference.

Considerable interest has been shown in the subject of feedback control in its relation to biological systems. Several papers on this subject will be available soon. It is planned to present one or more of these papers at the Summer General Meeting in Toronto, and a full session on biological systems will be included in the Conference on Feedback Control Systems in the fall.

R. W. Jones has been appointed Chairman of a newly formed Subcommittee on Bibliography. This subcommittee will co-operate with a similar one under the Committee on Industrial Control in compiling a bibliography on feedback control systems. Co-operation will be facilitated by the fact that Professor Jones is chairman of both interested subcommittees.

Power Division

Committee on Relays. (*E. L. Michelson, Chairman; A. J. McConnell, Vice-Chairman; J. R. Linders, Secretary.*) Several of the project committees of the Relay Committee have been quite active in recent months. The Transmission Line Project Committee is at present planning a paper on Backup Protection, which will present information on methods now being used in various power systems to obtain backup protection. In the near future this committee expects to publish a pamphlet consisting of basic papers in relay protection which have been published in AIEE *Transactions.* This publication will be made available to the AIEE membership and should serve as a valuable reference in its field.

The Project Committee on Remote Tripping has prepared a comprehensive questionnaire on methods now being used for remote tripping by power systems. This questionnaire has been sent to a large number of representative companies, and eventually information obtained from this questionnaire will be presented to the Institute.

The Project Committee on Relay Vibration and Shock has had several meetings and has developed a program of study in this field. Measurements of typical cases of vibration and shock have been made, and more are planned for the future. There has been considerable interest developed on this subject due to the numerous cases that have occurred of false tripping of relays due to vibration or shock.

The Project Committee on Pilot Wire Protection is bringing up to date the information presented several years ago on experience with pilot wires used for relay protection.

The next meeting of the Relay Committee will be held in Cleveland in the latter part of May.

Committee on System Engineering. (*R Brandt, Chairman; H. L. Harrington, Vice-Chairman; O. W. Manz, Jr., Secretary.*) It has been recommended that the Interconnection Contracts Subcommittee be terminated. However, before being disbanded, it was decided that the subcommittee prepare a check list of operating considerations to be included in interconnection contracts.

The System Operations Subcommittee was assigned the duty of studying the problem of system voltage control and preparing a session on this subject for the Summer General Meeting in Toronto. Other subjects assigned to this subcommittee are spinning reserve, out-of-step blocking relays, communication facilities for system operation, steady-state stability of lines under various conditions of generation, and limitations of turbogenerators.

Fault Limiting Devices Subcommittee of Protective Devices Committee. (*E. G. Norell, Chairman.*) The Guide for Application of Ground Fault Neutralizers deals with a special type of grounding for power transmission and distribution systems. This guide is described in the February issue of *Electrical Engineering,* pages 166–67. The working group preparing this guide is under the chairmanship of Mr. J. E. Clem and comments should be sent to him in care of the General Electric Company, Schenectady, N. Y.

The Application Guide for Grounding Synchronous Generator Systems presents the basic factors which must be evaluated in selecting a grounding scheme. These factors include: 1. Sensitivity and selectivity of ground relaying. 2. Limitation of magnitude of ground-fault current. 3. Limitation of transient overvoltages. 4. Application of lightning arresters to give curve voltage protection. The guide also describes the grounding equipment available a
makes recommendations on their applic
tion. This guide has been prepared by
working group under the chairmanship
Mr. A. A. Johnson. Comments should
sent to him in care of the Westinghou
Electric Corporation, East Pittsburgh, Pa.

Science and Electronics Division

Committee on Basic Sciences. (*M.
Malti, Chairman; Dimiter Ramadanoff, Vi
Chairman; W. C. Johnson, Secretary.*) T
Committee on Basic Sciences has been givi
special attention recently to: (a) magne
materials at high frequencies; (b) sen
conductors; (c) new techniques of netwo
syntheses; and (d) electric breakdown
gases. One session and four conferenc
were held on these subjects at the Wint
General Meeting.

The committee has agreed to divide t
Subcommittee on Electrical Properties
Solids and Liquids into two subcommittees
one on semiconductors, and the other
dielectrics. Dr. C. B. Brown of White Oa
Md., will be Chairman of the Subcommitt
on Semiconductors, and Dr. L. J. Berberi
of Westinghouse Electric Corporation w
be Chairman of the Subcommittee on D
electrics.

The Committee on Basic Sciences furth
approved the establishment of a new Su
committee on Defense. This subcommitt
will comprise a representative of each of t
three armed forces—Army, Navy, and A
Force. Its general object will be to c
operate with the armed services in t
technological phase of the defense of o
country.

AIEE PERSONALITIES . . . . .

F. O. McMillan Nominated for Institute President

Fred Orville McMillan (A '14, M '26, F '32, Member for Life), Head, Electrical Engineering Department, Oregon State College, Corvallis, Oreg., has been nominated for the presidency of the AIEE for the 1951–52 term. He was born May 12, 1890, in Albia, Iowa, and holds the degrees of bachelor of science in electrical engineering (1912) from Oregon State College and master of science in electrical engineering (1919) from Union College. He entered the Testing Department of the General Electric Compar
Schenectady, N.Y., in 1912 and transferr
to the Engineering Department in 1914 whe
he was engaged in design engineering for
years. In 1920 he was appointed to the ele
trical engineering faculty at Oregon Sta
College as assistant professor and becar
associate professor in 1923, research profess
in 1930, and professor of electrical engine
ing and Head of the Electrical Engineeri
Department in 1937. In addition to
academic work, Mr. McMillan has acted
consulting engineer for a number of pub
utilities, The Port of Portland, Oregon,
1925, and the United States Bureau of Fis
eries from 1929 to 1933. He was appoint
electrical engineering specialist to assist t
Chinese Government with problems in Chi
during 1943 and 1944. Much of his resear
work has been in the field of high-volta
phenomena including the grounded sphe
gap polarity effect and radio interferen
from high-voltage lines and associated equi
ment. This work has been reported in AI
papers and other publications. He
served on the following AIEE committe
Student Branches (1930–36, 1949–51, Cha
man 1949–51); Electrophysics (1934–3
Research (1934–41); Transfers (1936–
Chairman 1939–41); Education (1939–4
Edison Medal (1950–52); Technical Pr
gram (1948–50); Award of Institute Pri

F. O. McMillan

49–50); and Publication (1949–51).
was Vice-President representing AIEE
trict 9 during 1934–36 and was elected a
rector in 1948. His society affiliations in-
de the American Association for the Ad-
ncement of Science, American Society for
gineering Education, Institute of Radio
gineers, Northwest Electric Light and
wer Association, and the Professional Engi-
ers of Oregon. He is also a member of
u Beta Pi, Sigma Xi, Eta Kappa Nu, and
i Kappa Phi.

50 Lamme Medal To Be Awarded to Bohn

nald Ivan Bohn (A '23, M '41, F '49),
ief electrical engineer, Aluminum Com-
ny of America, Pittsburgh, Pa., has been
ected to receive the 1950 AIEE Lamme
edal "for his pioneering development
d application of electrical equipment
controlling rectifying systems in the
oduction of aluminum." Mr. Bohn was
rn November 29, 1896, in Chicago, Ill.,
d was graduated from the University of
isconsin in 1921 with the degree of bachelor
science in electrical engineering. For
o years following his graduation, Mr.
hn was associated with the General Electric
mpany. In 1923, he became assistant
ctrical superintendent, Aluminum Com-
ny of America, and has been appointed
ccessively electrical superintendent (1926);
istant chief electrical engineer (1928);
d in 1946 Mr. Bohn was made chief
ctrical engineer. He has written many
hnical articles and has many patents to
credit. Mr. Bohn carried on original
earch in the field of electric resistance
welding of aluminum and designed and developed one of the first spot welders, co-ordinating application of pressure and energy. Mr. Bohn was in charge of the first large installation of mercury arc rectifiers in the industry in the United States. He was a consultant in the design of eight aluminum reduction plants, totalling 1,500,000 kw, built by the Aluminum Company of America for the United States Government during World War II. Mr. Bohn is also a member of the Association of the Iron and Steel Engineers.

D. I. Bohn

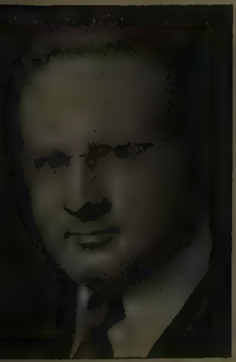
Vice-Presidential Nominees Are Strasbourger, Harper, Norris, Lovell, and Way

Julius C. Strasbourger (A '31, M '40), supervising engineer, Electrical Department, Cleveland Electric Illuminating Company, Cleveland, Ohio, has been nominated to serve the Institute as Vice-President representing the Middle Eastern District (number 2). Mr. Strasbourger was born in Cleveland, Ohio, on December 22, 1906, was graduated from the University of Cleveland in 1929 with a degree in electrical engineering, and acquired his bachelor of laws degree in 1934 from the Cleveland Law School. Mr. Strasbourger became associated with the Cleveland Electric Illuminating Company in 1929 and began his work there as an electrical engineer. He has worked in relay testing and field engineering, system operation, and procurement and mechanization. He has served the Institute as Section Chairman (1946–47) and on the following AIEE committees: Planning and Co-ordination (1946–49); Sections (1946–50, Chairman, 1947–49); Committee on Award of Institute Prizes (1948–49); and Safety (1950–51).

John Dickson Harper (A '34, M '40, F '50), assistant district power manager, Aluminum Company of America, Alcoa, Tenn., has been nominated to serve the Institute as Vice-President representing the Southern District (number 4). Mr. Harper was born on April 6, 1910, at Louisville, Tenn., and was graduated from the University of Tennessee in 1933 with a bachelor of science degree in electrical engineering. Following graduation he became an employee of the Aluminum Company of America and was successively an apprentice electrical engineer; junior electrical engineer in 1934; electrical engineer in 1936; chief load dispatcher in 1938; assistant superintendent of power in 1942; and he was appointed to his present position in 1943. Mr. Harper is the author of several articles which have been published in the technical press. He has served the Institute as Chairman, East Tennessee Section, 1944–45, and on the following committees: Nominating (1945); Electrochemistry and Electrometallurgy (1946–47); Chemical, Electrochemical, and Electrothermal Applications (1947–51); Industrial Power Systems (1950–51); Transfers (1948–51); and Membership (1949–51). Mr. Harper is also a member of The American Society of Mechanical Engineers, National Society of Professional Engineers, and Tau Beta Pi.

Ferris Waldo Norris (A '19, M '26, F '45), professor and Chairman, Electrical Engineering Department, University of Nebraska, Lincoln, Nebr., has been nominated to serve the Institute as Vice-President representing the North Central District (number 6). He was born in Beemer, Nebr., on December 4, 1894, and was graduated from the University of Nebraska in 1916 with a bachelor of science degree in electrical engineering, and received his master of science degree from there in 1925. Mr. Norris was associated with the General Electric Company as a testing electrical engineer from 1917 to 1919, and from 1919 to 1920 as a development engineer in the Lightning Arrester Engineering Department. In 1920 Mr. Norris was appointed an instructor in the Department of Electrical Engineering at the University of Nebraska, and was successively assistant professor, associate professor, and in 1943 was made a full professor. He is the author of several published technical articles. He served the Institute as Chairman of the Nebraska Section from 1937 to 1938. Mr. Norris is a member of the American Society for Engineering Education and served as President of the Kansas-Nebraska Section from 1949 to 1950. He is also a member of the Institute of Radio Engineers, Sigma Xi, and Eta Kappa Nu.

Nelson Mitchell Lovell (A '40, M '47), Vice-President, superintendent, Tuscon Gas, Electric Light and Power Company, Tuscon, Ariz., has been nominated to serve the Institute as Vice-President representing the Pacific District (number 8). Mr. Lovell was born on September 14, 1910, at Taylorville, Ill., and was graduated from the University of Illinois in 1934 with a bachelor of science degree in electrical engineering. His association with the Tuscon (Ariz.) Gas, Electric Light and Power Company, began in 1938.



J. C. Strasbourger

J. D. Harper

F. W. Norris

N. M. Lovell

Until 1937 Mr. Lovell served as an engineering clerk at which time he became a draftsman doing electrical drafting and system design. In two years Mr. Lovell became an engineering assistant, and in 1942 he advanced to general foreman and assistant electrical engineer. In 1947 the candidate was promoted to the position of electrical superintendent and in 1950 he was elected a Vice-President of the company. Mr. Lovell served the Institute on the System Engineering Committee (1949–51).

William Russell Way (M '42), general superintendent, Generation and Transmission Department, Shawinigan Water and Power Company, Montreal, Quebec, Canada, has been nominated to serve the Institute as Vice-President representing the Canadian District (number 10). Mr. Way was born in North Bay, Ontario, Canada, on May 29, 1896, and was graduated from McGill University in 1918 with a degree of bachelor of science in electrical engineering. Mr. Way has been associated with the Shawinigan Water and Power Company since 1918. His first position was that of assistant engineer; in 1924 he was transferred to Shawinigan Falls in the capacity of chief system operator. In 1930 he was made assistant superintendent of operation, subsequently assistant general superintendent, and in 1944 he was appointed general superintendent, Operating Department, in charge of generation, transmission, system operation, system planning, and communication. Mr. Way served the Institute as District Vice-Chairman (number 10) from 1947 to 1948. He has also served on the Power Generation Committee (1945–46) and the Membership Committee (1947–49). He is also a member of the Engineering Institute of Canada and the Canadian Electrical Association, and he represented the Chairman of the Canadian National Committee of C.I.G.R.E. in Paris, France, June 1950, at the Administrative Council Meeting.

Benedict, Danner, and Ewing Nominated for Directorships

Frank R. Benedict (A '40, M '47), director of engineering and research, Atomic Power Division, Westinghouse Electric Corporation, East Pittsburgh, Pa., has been nominated to serve on the AIEE Board of Directors. Mr. Benedict was born on January 21, 1907, in Perry Center, New York, and was graduated from Tri-State College with a bachelor of science degree in electrical engineering in 1928. Following graduation, Mr. Benedict entered the student course of the Westinghouse Electric Corporation, and the next year he was transferred to the engineering laboratories of the company. In 1936 he was made engineer in charge of the Impulse Laboratories. He held this post for two years and then was made liaison engineer; three years later Mr. Benedict was manager of the Engineering and Service Department of the New England district. In 1945, he was manager of the Industry Engineering Department, and in 1950 the candidate was appointed director of engineering and research of the Atomic Power Division of the company, with the responsibility for planning and coordinating the company's activities in nuclear power. Mr. Benedict has served the Institute on the following committees: Chemical, Electrochemical, and Electrothermal Applications (1946–51, Chairman 1948–50); Industry Co-ordination (1948–50); Standards (1947–51); Technical Program (1948–50); and Publication (1949–51).

Ronald Fackler Danner (A '29, M '34, F '45), manager, Engineering and Construction Department, Oklahoma Gas and Electric Company, Oklahoma City, Okla., has been nominated to serve on the AIEE Board of Directors. Born in Astoria, Ill., on November 2, 1897, Mr. Danner was graduated from the University of Oklahoma with a bachelor of science degree in electrical engineering in 1920. For one year following graduation Mr. Danner was employed by the Westinghouse Electric Corporation as a student engineer, and in 1921 he became associated with the Oklahoma Gas and Electric Company as a distribution engineer. He became assistant to the general superintendent two years later, general superintendent in 1926, and in 1948 Mr. Danner was made manager of engineering and construction. He served the Institute as Vice-President representing the Southwest District (number 7) from 1946 to 1948 and has served on the following AIEE committees: Power Transmission and Distribution (1940–45); Industrial Control Devices (1946–47); and Technical Program (1947–48). Mr. Danner is also a member of the National Society of Professional Engineers and Eta Kappa Nu.

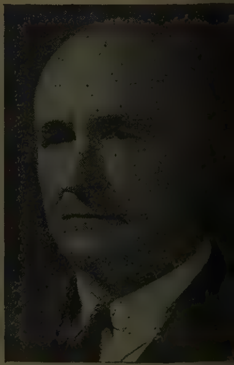
Dressel DeWitt Ewing (A '11, M '14, F '21, Member for Life), Head, School of Electrical Engineering, Purdue University, Lafayette, Ind., has been nominated to serve on the
AIEE Board of Directors. Doctor Ew
was born on October 7, 1883, and was gra
ated from Ohio Northern University in 19
In 1907, Doctor Ewing returned to O
Northern University, Ada, Ohio, as an
structor in electrical and mechanical en
neering. In 1912 he entered Purdue U
versity, Lafayette, Ind., as a graduate stud
and a year later he was appointed assist
professor of electrical engineering. In 1
Doctor Ewing was appointed associate p
fessor, and in 1918 professor of electric r
way engineering. At Purdue his spec
fields of work for many years have been
electric power and electric railways. He
came Head of Purdue's School of Electri
Engineering in 1942. He is the author
several articles published by the techni
press and served from 1922 to 1932 as a me
ber of the Joint Committee on Welded Ra
way Joints sponsored by the American We
ing Society, the American Transit Assoc
tion, and the National Bureau of Standar
In 1936 he received an honorary degree
doctor of engineering from Ohio Northe
University. Doctor Ewing has served on t
following AIEE committees: Electric We
ing (1932–44); Power Transmission a
Distribution (1936–42); Transportati
(1936–42); and Code of Principles of P
fessional Conduct (1942–50, Chairman 194
47). Doctor Ewing's society affiliations
clude: American Society for Engineeri
Education; Tau Beta Pi; Eta Kappa N
and Sigma Xi.

Tomlinson Fort (A '27, M '35), manag
apparatus sales, Westinghouse Electric C
poration, Pittsburgh, Pa., **L. W. McLe**
(A '43, M '45), southwestern district ma
ager, Westinghouse Electric Corporation,
Louis, Mo., and **E. W. Loomis** (A '
M '45), middle Atlantic district manag
Westinghouse Electric Corporation, Phi
delphia, Pa., have been elected Vice-Pre
dents of the company. Mr. Fort has be
with the company since 1923, holding sa
positions in Albany, N.Y., New York Ci
and Pittsburgh, Pa. Mr. Fort served t
Institute on the Membership Commit
(1943–49, Chairman 1946–48), and the Sp
cial Committee on Registration of Engine
(1942–44). Mr. McLeod has been w
Westinghouse since 1925. He has held sa
positions in Houston, Tex., San Anton
Tex., Wichita, Kans., and Memphis, Ten
before being assigned to the St. Louis office
1939 as central station division manag
He was appointed southwestern district ma
ager in 1946. Mr. Loomis has been manag
of the middle Atlantic district since 19

W. R. Way

F. R. Benedict

R. F. Danner


D. D. Ewing

joined the company in 1914 as a graduate
ient at the East Pittsburgh Works, and
n 1915 to 1931 he was in the New York
y sales office.

V. Erben (M '43), Vice-President, gen-
l manager, Apparatus Department, Gen-
l Electric Company, New York, N.Y.,
l **H. L. Andrews** (A '16, M '26), Vice-
sident, Appliance and Merchandise De-
tment, General Electric Company,
dgeport, Conn., have been elected Execu-
e Vice-Presidents. Mr. Erben was gradu-
d from Yale University in 1919 with a
ree in mechanical engineering. He
ned General Electric in 1920 as a student
ineer on the Test Course. In 1923 he
s transferred to the Apparatus division of
Central Station Department. In 1939
er successive promotions he was appointed
stant manager of the Central Station
partment and two years later, general
nager. In 1948, Mr. Erben was elected
ce-President and general manager of the
paratus Department. Mr. Andrews was
duated from the University of Missouri in
0 with the degree of bachelor of science in
ctrical engineering and became associated
h General Electric that year. Mr.
drews worked in the Railway Engineering
partment and in 1929 he was advanced to
post of engineer in that department. In
4, Mr. Andrews was elected a Vice-Presi-
t and put in charge of steam railroad elec-
ication, and one year later became re-
nsible for all of the company's transpor-
on activities. In 1939, Mr. Andrews was
ced in charge of the Appliance and Mer-
ndise Department. He served the Insti-
e as member of the Transportation Com-
tee (1932–34).

V. Berkner (A '29, F '47), staff member,
negie Institution of Washington, Wash-
ton, D.C., has been elected President of
ociated Universities, Inc. Associated
iversities, Inc., is the nonprofit corpo-
on formed by nine eastern universities to
ninister Brookhaven National Laboratory,
ler contract with the Atomic Energy Com-
sion. To accept his new office, Mr.
kner is resigning from the staff of the
negie Institution of Washington. Mr.
kner was born in Milwaukee, Wis., in
5, took a bachelor of science degree in
trical engineering at the University of
nesota in 1927, and later studied physics
George Washington University. He was
engineer and pilot in the Byrd Antarctic
edition, 1928–30. From 1933 to 1941,
erved as research physicist in the Depart-
t of Terrestrial Magnetism, Carnegie
itution. From 1941 to 1946 he organized
headed the Electronics Materiel Branch,
eau of Aeronautics, United States Navy
artment, and in 1947 he served as execu-
secretary of the Research and Develop-
t Board. In 1949, Mr. Berkner became
ial assistant to the Secretary of State
g work relating to the Military Assist-
e Program. Mr. Berkner is a fellow of
American Physical Society and of the
itute of Radio Engineers and a member
he National Academy of Sciences, Na-
al Research Council, and the American
ciation for the Advancement of Science.
erved on the AIEE Research Committee
9–51).

E. H. Howell (A '42), sales manager, Meter and Instruments Divisions, General Electric Company, Lynn, Mass., has been appointed special representative of the company's Apparatus Department in Washington, D.C. In his new post, Mr. Howell will direct his activities specifically to liaison with governmental agencies created in connection with the national defense program. He was graduated from the Georgia School of Technology with a bachelor of science degree in electrical engineering in 1922. He joined the staff of General Electric that same year, and two years later was transferred to the company's Pittsfield, Mass., Works for sales training. In 1930 Mr. Howell was named manager of the Toledo, Ohio, office, a post he held for 13 years. In 1943, he was promoted to manager of sales of the Meter and Instruments Divisions. **D. E. Craig** (A '45, M '48), assistant sales manager, Meter and Instrument Divisions, General Electric Company, Lynn, Mass., has been named to succeed Mr. Howell as manager of sales. Mr. Craig was graduated in 1932 from South Dakota State College with a bachelor of science degree in electrical engineering. Following his graduation, he was connected for several years with the Municipal Light and Power Department, Sioux Falls, S. Dak. In 1937, Mr. Craig became associated with the General Electric Company in the Distribution Systems Divisions. Subsequently, he was engaged in promotion and development of unit substations, and, in 1945, was appointed manager of sales for the unit substation section. In 1949, he was named assistant sales manager of the Meter and Instrument Divisions.

D. R. Hull (M '48), assistant manager, Equipment Division, Raytheon Manufacturing Company, Waltham, Mass., has been elected Vice-President of the company. Captain Hull (retired, United States Navy) was graduated from the United States Naval Academy in 1925. In 1933 he received a master of science degree from Harvard University. He was on continuous naval service from 1921 to 1948. During the decade prior to World War II Captain Hull specialized in underwater sound and radar development. He initiated the design and operational use of very-high-frequency radiotelephone equipment for fleet tactics. For his services in the last war he was awarded the Legion of Merit and the Navy Commendation Ribbon. Following the war, Captain Hull was Executive Vice-President of Capehart-Farnsworth Corporation, a Vice-President and Director of Federal Telecommunications Laboratories, and assistant technical director of International Telephone and Telegraph Corporation. He joined Raytheon in 1949.

N. M. DuChemin (A '29, M '47), assistant general manager, Apparatus Department, General Electric Company, Lynn, Mass., has been named manager of the Small Apparatus Department. Mr. DuChemin is a graduate of St. Bonaventure College, Newfoundland. He became associated with General Electric in 1914 where he advanced to the position of general superintendent in 1923. He was appointed assistant works manager in 1935, acting manager in 1942, and in 1943 works manager. In 1947, he was named manager of the meter and instrument divisions, and in 1949 an assistant general manager of the Apparatus Department. Mr. DuChemin is also a member of The American Society of Mechanical Engineers.

A. M. Zarem (A '43, F '50), Director, Los Angeles Division, Stanford Research Institute, Los Angeles, Calif., has been voted one of America's Ten Outstanding Young Men of 1950 by the United States Junior Chamber of Commerce. Doctor Zarem has concerned himself directly with the major problems facing the future development of Southern California—mass transportation, water resources, and air pollution or smog. He has won several awards based on his development of photograph techniques. The Zarem Camera, so named by the United States Navy, has a speed of 100,000,000 frames per second and an effective exposure time as fast as 1×10^{-9} second, the fastest known to science. Doctor Zarem is currently serving the Institute on the Electronics Committee.

OBITUARY • • • • • •

Edward Bennett (A '01, M '13, F '18, Member for Life), professor emeritus of electrical engineering, University of Wisconsin, Madison, Wis., died on January 10, 1951. He was born on October 26, 1876, in Pittsburgh, Pa., and received the degree of electrical engineer from the University of Pennsylvania in 1897. Following graduation he became associated with the Westinghouse Electric and Manufacturing Company, now the Westinghouse Electric Corporation, and became engaged in research work on lightning arresters. He invented and produced the first multipath lightning arresters which were placed on 600-volt railway systems. He also worked on the development of the Nernst lamp. During the period from 1906 to 1909, Mr. Bennett was with the Telluride Power Company of Utah conducting investigations dealing with high-voltage problems. In 1909 he accepted an associate professorship in electrical engineering at the University of Wisconsin. In 1917 he was appointed Chairman of Electrical Engineering, a post which he held until his retirement in 1943. His memberships in other societies included the American Physical Society, the American Society for Engineering Education, the Institute of Radio Engineers and Sigma Xi. Mr. Bennett was an active member of the AIEE, having served as Vice-President from 1924 to 1926. The Institute committees he served on include the following: Education (1920–35, Chairman 1928–30); Research (1922–32); Board of Examiners (1924–25); Meetings and Papers (1928–30); Student Branches (1928–30, 1936–38); Standards (1939–50).

Louis Bevier Spinney (A '03, M '04, Member for Life), professor of physics, Iowa State College, Ames, Iowa, died on January 25, 1951. Born in Bradford, Ill., May 27, 1869, Doctor Spinney was graduated from Iowa State College with the degree of bachelor of engineering in 1892 and received the degree of bachelor of science in electrical engineering in 1893. He also did graduate work at the University of Berlin, Germany, Polytechnikum of Zurich, Switzerland, and Cornell University. In 1948 he was awarded the degree of Doctor of Science by Iowa State College. In 1893 Doctor Spinney became an instructor at Iowa State and six years later he was appointed Head of the Department of Physics and Electrical Engineering. In 1909 the department was split up and Doctor Spinney remained as Head of the Physics Department. He retired from administrative duties in 1942, but remained on the faculty as professor of physics until the time of his death. He was also a member of the American Physics Society, the American Association for the Advancement of Science, and the Illuminating Engineering Society.

William J. Knightley (A '37, M '48), division plant superintendent, Southwestern Bell Telephone Company, Wichita, Kansas, died on January 25, 1951. He was born on January 17, 1893, in Wichita, and was graduated from the University of Wichita in 1933. Mr. Knightley became associated with the Southwestern Bell Telephone Company in 1915 as supervisor of maintenance in various operating districts of the company. In 1948 Mr. Knightley was made superintendent of the Southern Kansas division of the company which included maintenance, engineering, and construction activities. He was an active member of the Institute and served as Section Chairman from 1939 to 1940.

Frank J. Pohnan (M '50), senior engineer, dielectrics section, Testing Department, Commonwealth Edison Company, Chicago, Ill., died on November 26, 1950. Mr. Pohnan was born in Vodolka, Czechoslovakia, August 29, 1898. He received his degree in electrical engineering from the State College of Engineering, Prague, Czechoslovakia, in 1920. Mr. Pohnan came to the United States the same year, and after a short period with the Western Electric Company, entered the Testing Department of the Commonwealth Edison Company in 1921. When the dielectrics section was formed in 1937, he became senior engineer and concentrated his efforts on the serviceability of high-voltage underground cables, generator armature insulation, and related dielectrics. Mr. Pohnan was a member of the Conference on Electrical Insulation, Division of Engineering and Industrial Research, National Research Council.

Roger M. Sanderford (A '43), electrical engineer, died on October 12, 1950. He was born on January 8, 1909, in Temple, Tex., and was graduated from Tulane University in 1942 with a bachelor of science degree in electrical engineering. Mr. Sanderford's experience was varied and included: association with Port Arthur College, Port Arthur, Tex., as instructor in the Radio Department; work in construction, installation, and operation of radio acoustic equipment for the United States Coast Guard; operation and maintenance of airways and aircraft equipment for Braniff Airways, Dallas, Tex.; and operation, maintenance, and installation of point-to-point radio telegraph equipment for Mackay Radio and Telegraph Company, New Orleans, La. Mr. Sanderford was also a member of the Institute of Radio Engineers.

Stanley Lewry Schauss (A '43, M '50), associate professor of electrical engineering, Cornell University, Ithaca, N. Y., died on January 24, 1951. He was born on September 2, 1908, in Brooklyn, N. Y., and in 1929 was graduated from Cornell University with the degree of electrical engineer. He received his master of science degree from New York University in 1938. From 1929 to 1934 Mr. Schauss was employed by Westinghouse Electric Corporation and following this association he became an instructor at Cooper Union, New York, N. Y. In 1942 he was appointed instructor in electrical engineering at Cornell University, Ithaca, N. Y., where he advanced to assistant and then to associate professor in 1949. Mr. Schauss was also a member of Eta Kappa Nu.

John Herman Mills (A '37), representative, American Lava Corporation, Chattanooga, Tenn., died on January 6, 1951. Mr. Mills became associated with the American Lava Corporation in 1931 as sales engineer.

MEMBERSHIP • • •

Recommended for Transfer

The board of examiners at its meeting of February 15, 1951, recommended the following members for transfer to the grade of membership indicated. Any objections to these transfers should be filed at once with the Secretary of the Institute. A statement of valid reasons for such objections, signed by a member, must be furnished and will be treated as confidential.

To Grade of Fellow

Chase, W. H., asst. vice pres., The Ohio Bell Telephone Co., Cleveland, Ohio
Faron, F. A., dist. mgr., General Electric Co., New York, N. Y.
Giering, P. L., engr., Stevenson, Jordan & Harrison, New York, N. Y.
Guillemin, E. A., electrical communications prof., Massachusetts Institute of Technology, Cambridge, M[illegible]
McDonald, J. A., supt. apparatus service shop, General Electric Co., Salt Lake City, Utah
Patterson, L. L., dean, emeritus, Mississippi State College, State College, Miss.
Snavely, A. B., chief engr., Hershey Chocolate Corp. Hershey, Pa.
Stahl, E. C. M., mgr., distribution operation dept., Consolidated Edison Co. of N. Y., Inc., New York, N. Y.

8 to grade of Fellow

To Grade of Member

Arnold, H. R., supervising engr., Westinghouse Electric Corp., Sharon, Pa.
Bapat, M. N., transmission supt., The Tata Hydro Companies, Fort Bombay, India
Breitenbach, P., elec. engr., radiation lab., University of California, Berkeley, Calif.
Brown, N. H. R., meter, relay & communications supt., Hydro Electric Power Commission, Toronto, Ontario, Canada
Campbell, E. O., chief installation & maintenance engr., International Standard Trading Corp., New York, N. Y.
Chatterjee, A. K., vice principal & head, elec. engg. dept., Birla Engineering College, Rajputana, India
Coffin, A. L., switchboard equipment engr., Western Electric Co., Chicago, Ill.
Cuttino, W. H., design engr., Westinghouse Electric Corp., East Pittsburgh, Pa.
Farris, G. G., engr., Oklahoma Gas & Electric Co., Muskogee, Okla.
Green, C. E. J., field engr., Leeds & Northrup Co., Cleveland, Ohio
Gregory, J. F., project engr., Colgate-Palmolive-
Co., Jeffersonville, Ind.
Haner, L. P., research supervisor, E. I. du Pon
Nemours & Co., Buffalo, N. Y.
Harrigan, M. A. P., chief elec. engr., Electric Tamp
Equipment Co., Ltd., Montreal, Quebec, Cana
Hesse, L. F., chief elec. engr., Gisholt Machine
Madison, Wis.
Hoover, V. A., owner, Hoover Electric Co., Los Ang
Calif.
Jenness, R. R., asst. prof. of elec. engg., Northwe
Univ., Evanston, Ill.
Meneses-Hoyos, R., Reforma #12, Mexico, D. F., M
Osborne, A. I., elec. drawing room supervisor, New
News Shipbuilding & Dry Dock Co., New
News, Va.
Pool, R., chief engr., power sta., Public Service C
Oklahoma, Tulsa, Okla.
Seidman, S. M., dist. plant engr., Ohio Bell Telep
Co., Cleveland, Ohio
Shortley, W. M., engr., Southern Bell Tel. & Tel.
Atlanta, Ga.
Sinclair, W. D., chief engr., Crisp County Power C
mission, Cordele, Ga.
Sitaram, M. M. R., asst. elec. inspector, Governm
of Mysore, Bangalore, India
Tarpley, J. W., distribution engr., City of Lubbock,
Tucker, S. A., publications mgr., American Socie
Mechanical Engineers, New York, N. Y.
VanVranken, W. P., application engr., Elliott
Ridgway, Pa.
Wallingford, L. E., fire control design engr., Navy D
Ordnance Bureau, Washington, D. C.
Wilson, F. M., elec. engr., U. S. Bureau of Recl
tion, Denver, Colo.
Woolsey, L. S., assoc. elec. engr., M. L. Crist &
ciates, Little Rock, Ark.

29 to grade of Member

Applications for Election

Applications for admission or re-election to Ins
membership, in the grades of Fellow and Member,
been received from the following candidates, and
member objecting to election should supply a s
statement to the Secretary before April 25, 19
June 25, 1951, if the applicant resides outside
United States, Canada, or Mexico.

To Grade of Member

Adams, R. L., California-Oregon Power Co., Rose
Oreg.
Bartlett, E. T., U.S.A.F., Chanute Field, Rantoul,
Becker, D. B., University Club, Madison, Wis.
Berry, H. A., Carthage Water & Elec. Plant, Cart
Mo.
Burns, R. O., U. S. Navy Electronics Lab., San D
Calif.
Cherry, L. B., Lamar College, Beaumont, Tex.
Clifford, D. G., Lenkurt Elec. Co., Inc., San C
Calif.
Corrigan, D. J., Westinghouse Elec. Corp., Balti
Md.
Dean, J. M., Delavan Engineering Co., Des M
Iowa
Gray, B. A., Dept. of Water & Power, Los Angeles,
Haq, Z., Government of Pakistan, Karachi, Pakist
Havelin, J. E., Philadelphia Elec. Co., Philadelphia
Holden, O., Hydro Elec. Power Comm. of Ont
Toronto, Ontario, Canada
Hyde, H., Toronto Hydro Elec. System, Tor
Ontario, Canada
Kay, J. M., Continental Elec. Co., Inc., Newark,
King, L. A., Jackson & Moreland, Boston, Mass.
Latzer, F. (re-election), 429—7th Ave., New York,
Lindsay, M. H. A., A. D. T. Co., Inc., New York,
Liuni, F., Int'l. Tel. & Tel. Corp., New York, N.
Longacre, E. C., Salt River Power District, Ph
Ari[illegible]
Mainardis, M., Sade-Societa di Elettricita, Venice,
Maltby, F. L., The Bristol Co., Waterbury, Conn
Mills, H. L., E. I. Du Pont de Nemours & Co., Au
Ga.
Minc, A., Mackay Radio & Telegraph Corp.,
York, N. Y.
Myers, R. J., Dept. of Communications, City of A
Ohio
Nayler, J. B., Aluminum Co. of Canada, Ltd., A
Quebec, Canada
Neil, J. P., Fahnestock Elec. Co., Inc., Long Island
N. Y.
Pitman, D. A., Marconi Instruments Ltd., New
N. Y.
Powers, S. J., Federal Tel. & Radio Corp., Clifton,
Rajk, M. N., Consultants & Designers, Inc., New
N. Y.
Roth, W. J., Jr., Engelhard Industries, East Ne
N. J.
Sarathy, V. P., B. E. S. & T. Undertaking, Bo
Undertaking, Bombay, India
Small, C. F., The Chesapeake & Potomac Tel
Washington, D. C.
Smith, L. R., Good-All Elec. Mfg. Co., Ogallala,
Stokes, H. L., S. C. Public Service Authority, M
Corner, S. C.
Streda, F. A., Canadian General Elec., Toronto, O
Canada
Swan, C. R., James G. Biddle Co., Philadelphia,
Torii, T., Japanese National Railways, Tokyo, Ja
Witt, L. C., Public Service Dept., Glendale, Cali
Zitman, M. E. C., Shell Caribbean Petroleu
Cardon, Estado Falcon, Venezuela, S. A.

40 to grade of Member

F CURRENT INTEREST

dmium Sulphide Crystal Used in X-Ray Inspection of Industrial Products

revolutionary discovery that promises ake possible for the first time the high- d, automatic X-ray inspection of sands of industrial products was an- ced recently by the General Electric ay Corporation, Milwaukee, Wis. The ose of inspecting these products is to ease their soundness and safety, and in ral to improve quality and help develop r production processes. The new in- tion system may also be used to improve performance of medical diagnostic and apeutic X-ray apparatus.

he heart of the new inspection system is y cadmium sulphide crystal, known as a conductor, which can be grown in size a fraction of a millimeter to several meters in cubic size. When excited with adiation, it acts as an amplifier tube, sing electrons that can be used to ate various types of mechanisms.

he crystals amplify the energy they ive 1,000,000 times. On an area-for- basis, they are over 1,000,000 times e sensitive to X rays than are ionization nbers which are commonly used to sure X radiation, and over 1,000 times e sensitive than photoelectric cells, such hose used in electric-eye applications.

he crystals are extremely sensitive, are le, and instantly respond to variations he intensity of X rays. Because of the 0,000-to-1 gain permitted by the crystals, do the work that hitherto required a h more complex system of vacuum tubes amplifiers, while at the same time allow- the use of low-intensity X rays. The ntists believe that the use of crystals as itive energy converters and amplifiers ns up a new field of crystal-electric neering.

ilot laboratory models have been built nspect rubber heels, the product level in y food, beer, soup, and other canned packaged products.

he crystal-electric method promises to orm at unprecedented speeds, ranging igh as 600 units per minute in the case anned foods and liquids. Operating as rt of industrial slave eye, the crystals solve many kinds of inspection problems, uding: (1) Controlling and checking product level in containers, (2) Detecting s, cracks, cavitation, and variation in erial thickness in a wide variety of homo- eous materials, (3) Checking for absence, lacement, or misalignment of inserts other internal parts, and even eventually, Spotting foreign particles in certain s, metals, and other products.

r. Rudolf Frerichs, scientist at the thwestern University Physics Depart- t, has been working as a consultant with John E. Jacobs, engineer of General tric X-Ray Corporation. They have growing the crystals in the company's lidge Laboratory. Doctor Jacobs re- ed his doctorate degree from the Electrical Engineering Department at Northwestern as a result of his work on the crystals with Dr. Frerichs.

A relay is in the device to call attention to any defective area. The relay can be made to do almost anything automatically—operate a meter, chart a graph, work a rejection lever to remove the product from the line, ring a bell, flash a light, dab red paint on the faulty part, or actually stop an entire production line until the faulty product or process is run down. This type of operation promises to reduce both the operating cost and the man power required for a given inspection operation.

Although the crystals used to detect small defects are tiny, they may be grown to larger sizes, and batteries of crystals may be arranged so as to integrate a large area. In general, the laboratory models do not use a large spray of X radiation, as do conventional X-ray machines or fluoroscopes, but rather narrow pencil-like beams. In some installations, this may mean that the radiation hazard will be greatly reduced, and the cost of building special concrete or lead partitioning would be either reduced or eliminated entirely.

General Electric X-Ray Corporation has experimented with controlling the output of the X-ray beam used with the crystal itself, stabilizing it within a very close range.

17,000,000-Volt Linear Accelerator in Use at MIT

A 17,000,000-volt linear accelerator which pushes electrons out of a 21-foot pipe with enough energy to crack the hard centers of target atoms is now in use in the Laboratory for Nuclear Science and Engineering at the

Cans of baby food are shown being tested in the Coolidge Research Laboratory of the General Electric X-Ray Corporation using the new crystal detection technique. Dr. J. E. Jacobs and Dr. Rudolf Frerichs of Northwestern University are responsible for the development. Facing the cans from the left is the crystal holder. To the right of the cans is the low-powered X-ray machine (45 kv, 3 milliamperes). On the table are a control box and the relay, used to actuate any mechanism that will reject faulty cans

Massachusetts Institute of Technology (MIT).

Completion of the new machine, which is expected to produce radiation equivalent to that from more than two pounds of radium, was announced recently. The new research tool will be used for experiments on nuclear structure and to verify or disprove hypotheses regarding the structure of matter and its interaction with radiation. Although its energy of 17,000,000 volts is not unusually high by comparison with other machines like the synchrotron, the accelerator will be useful because of its intense and narrow X-ray beam and its neutron output.

The linear accelerator, though now in use by the Laboratory for Nuclear Science and Engineering, was built by the MIT Research Laboratory of Electronics, with funds provided by the Air Materiel Command, Office of Naval Research, and Signal Corps. Its construction was under the general direction of Prof. John C. Slater, head of the MIT Physics Department, who originated the design. Dr. Arthur F. Kip, assistant professor of physics, was in direct charge of its construction for the Research Laboratory of Electronics.

Research with the accelerator in the Laboratory for Nuclear Science and Engineering will be financed in part by the Atomic Energy Commission and the Office of Naval Research.

Electrons shoot into the linear accelerator at nearly the speed of light from an electrostatic generator. They rush the length of the 21-foot tube by riding on waves of high-frequency electricity, acquiring more speed and energy. At the end of the tube, electrons with up to 17,000,000 volts of energy enter a vacuum-tight metal box. In their collisions with atoms in their path, these electrons knock out neutrons and high-energy X rays, which fly like hot popcorn in all directions. These factors will be of great importance for studying nuclear structure.

Scientists Develop New Technique for Studying Corrosion

A new technique, designed to measure the effects of corrosive solutions, may reduce substantially the nation's annual corrosion costs, estimated at $5.5 billion, or about $37 per person.

Developed at Armour Research Foundation of Illinois Institute of Technology, Chicago, Ill., under the sponsorship of the National Advisory Committee for Aeronautics, the new method is similar to television scanning and can be used for detection, study, recording, and analysis of corrosion phenomena.

Scientists now can measure corrosion as it takes place, regardless of the metal involved. Corrosion, of which rust is an example, is caused by thousands of local cells similar to microscopic flashlight batteries. The electrochemical cells are formed by corrosive chemicals and the metal itself. By studying the action of these tiny, unwanted electric cells, electrochemists can learn more of the fundamental facts regarding corrosion.

The laboratory sample on which corrosion occurs is a metal cylinder. This cylinder is dipped in some corrosive solution such as sea water, rotated several hundred times a minute, and scanned with a stationary probe electrode.

The probe electrode, which is a plastic arm containing 11 silver wires, is placed about 0.02 inch away from the submerged cylinder. It picks up the minute electric currents caused by corrosion and enables scientists to measure and study the process. These tiny currents can be amplified and viewed on an oscilloscope screen or photographed for later analysis.

One advantage of this method is that it permits easier and faster study of the entire surface area of a corrosion sample. The new technique can be used for investigations of cathodic protection, corrosion inhibitors, stress corrosion, and in fundamental corrosion studies.

Sounds You Can See but Cannot Hear

High-frequency sound waves beyond the range of the human ear are proving to be a useful tool for research and for industry. Scientists find them useful for mixing such naturally insoluble substances as oil and water, or mercury and water. Industrialists find them useful for nondestructive testing of metal castings and concrete structures, and for mixing paint pigments. Scientists see a future for ultrasonics for improving clothes washers, for agglomerating smoke particles, for pasteurizing milk, for sterilizing containers, and for many other uses.

At the Westinghouse Research Laboratories studies of the fundamental properties of these waves are being made. Westinghouse scientists feel these studies will lead to new uses for them. The source of these waves is an ultrasonic generator, shown below. It is being demonstrated by Dr. Patrick Conley, physicist at the Laboratory, who is conducting the unique research project.

Future Meetings of Other Societi

American Materials Handling Society. Mater
Handling Conference held concurrently with the
tional Materials Handling Exposition. April 30–M
4, 1951, International Amphitheatre, Chicago, Ill.

American Society for Quality Control. Fifth Natic
Convention. May 23–24, 1951, Hotel Clevela
Cleveland, Ohio.

American Society of Mechanical Engineers. Spr
Meeting. April 2–5, 1951, Atlanta Biltmore Ho
Atlanta, Ga.

Greater New York Industrial Show. Sponsered
the Technical Societies Council. May 7–11, 19
71st Regiment Armory, 34th Street and Park Aven
New York, N. Y.

Illuminating Engineering Society. Southern Meeti
April 9–10, 1951, Atlantis Hotel, Miami Beach, Fla.

Illuminating Engineering Society. Great La
Meeting. May 24–25, 1951, Hotel Gibson, Cincinn
Ohio.

Institute of Radio Engineers. Southwestern C
ference. April 20–21, 1951, Southern Methodist U
versity, Dallas, Tex.

Institution of Electrical Engineers. Conference
Electrical Instrument Design. May 28–31, 1951, T
Institution Building, London, England.

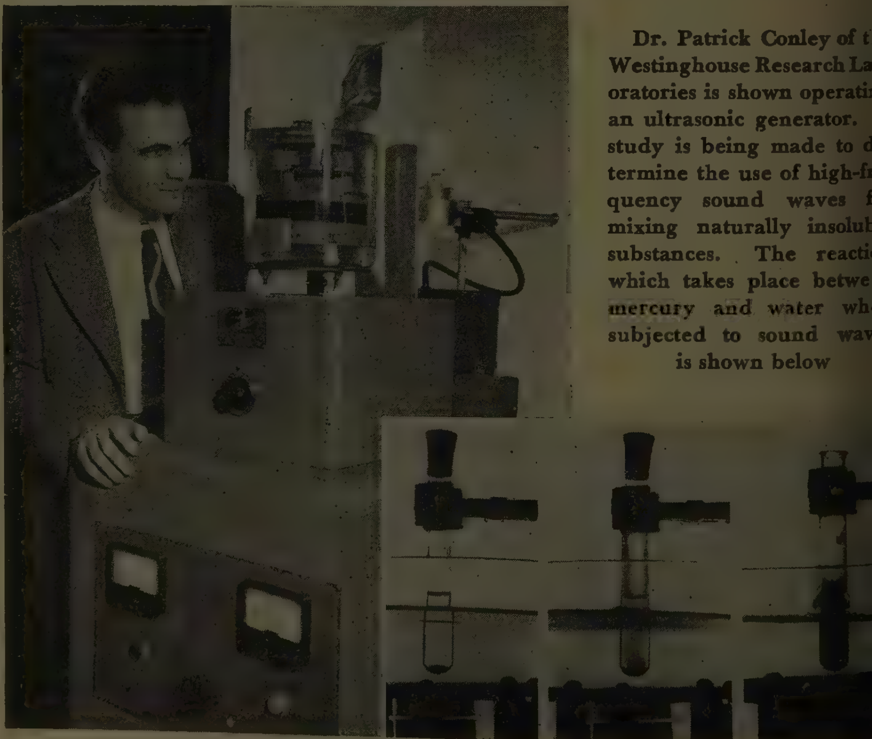
Midwest Power Conference. 14th Annual C
ference. April 4–6, 1951, Sherman Hotel, Chicago,

National Conference on Airborne Electronics. Sp
sored jointly by the Professional Group on Airbo
Electronics and the Dayton Section of the Institute
Radio Engineers. May 23–25, 1951, Biltmore Ho
Dayton, Ohio.

New England Radio Engineering Meeting. Sp
sored by the North Atlantic Region of the Institute
Radio Engineers. April 21, 1951, Copley Plaza Ho
Boston, Mass.

Society of Motion Picture and Television Engine
Spring Convention. April 30–May 4, 1951, Ho
Statler, New York, N. Y.

The jar of oil atop the generator contains the heart of the device; a tiny quartz cryst
The application of an electronica
generated, high electric voltage across t
crystal causes it to vibrate about 750,0
times a second. These vibrations crea
ultrasonic waves; the ultrasonic wav



**Dr. Patrick Conley of t
Westinghouse Research La
oratories is shown operati
an ultrasonic generator.
study is being made to d
termine the use of high-fr
quency sound waves f
mixing naturally insolub
substances. The reacti
which takes place betwe
mercury and water wh
subjected to sound wav
is shown below**

ate the molecules in the liquid and, if inued long enough, complete mixing or lsification takes place. This action is trated in the series of three photographs vn on the preceding page.

or these pictures, the test tube was filled water and mercury and immersed in the illed jar a few inches from the crystal. the left-hand photograph, the reaction just gotten under way—the globule of cury is visible in the bottom of the tube. the impact of the sound waves takes ct, a cloud of minute particles of mercury ns in the water. Complete mixing or lsification of the two liquids is achieved the right-hand photograph. Internal sure blew the cork out of the test tube.

o make these sound-wave pictures, the n was darkened and light from a mono-omatic source was beamed through the e of ground glass held by Doctor Conley. ie exposures up to one minute were ded to register the waves on the photo-hic film.

reative Frontiers," New TV Program, to Be Broadcast Soon

Creative Frontiers" will be a 1-hour vision program highlighting pioneering and women, known or unknown, who working on new advances in science, stry, or the arts. Each week a different anization of the advisory board will be for "Creative Frontiers" and will ure a new idea in one of the fields, and man or woman behind it.

he first 40 minutes of the program will the human interest personal story of the neer and his work as interpreted by a of actors. Following the dramatic rpretation, the true creator will appear a trio of prominent men to discuss the being presented.

he Advisory Board of "Creative Fron-s" includes: American Institute of ctrical Engineers, American Association the Advancement of Science, The erican Federation of Art, American iety of Civil Engineers, American In-ite of Mining and Metallurgical Engi-rs, The American Society of Mechanical gineers, American Institute of Chemical gineers, New York Chapter of the Ameri- Institute of Architects, and The Berkshire sic Center.

n Executive Council representing the ups has been set up to supply the program critics and guest creators. Since e organizations cover the major area in r fields, they are in a position to hear of newest inventions and creative ideas before the press does.

n the event that a "Talent Hunt" is rporated into the program, the organiza-s have agreed to co-operate in conducting nation-wide search for creative talent. award will be presented in the different ds by each group for the most worthy tive idea and help will be given to elop the idea into an achievement.

fund will be established and each anization which acts as host on a specific ning will receive a stipulated sum for arch, scholarship, or awards. "Creative ntiers" will be broadcast over a nation-e hook-up sometime this spring.

For information or for suggesting creators, write to C. Raeder, 615 Eastern Parkway, Brooklyn, N. Y.

GE Builds Its Largest Metal-Enclosed Drawout Switchgear

The largest metal-enclosed drawout switchgear for heavy-duty d-c service ever built by the General Electric Company has been put in service in the blooming-mill motor room of Jones and Laughlin Steel Corporation's Otis Works at Cleveland, Ohio.

The switchgear consists of 18 circuit-breaker and control units which control two 1,000-kw 250-volt ignitron rectifiers, a 1,500-kw 250-volt motor-generator set, and 12 automatic reclosing feeder circuits. In addition to the heavy-duty d-c circuit breakers in the rectifier cathode circuits, the installation includes high-speed metal-enclosed drawout anode circuit breakers for the rectifiers; these are located in separate structures adjacent to the rectifiers.

The General Electric Switchgear Divisions, which manufactured the equipment, only recently extended their line of metal-enclosed switchgear to the field of heavy-duty d-c service in steel mills. The new line also meets the needs of other large industrial establishments and large d-c traction substations.

Built for use on 250- and 600-volt d-c systems in ratings up to 8,000 amperes, the new line of switchgear equipment utilizes the heavy-duty Type *MC*-5 magnetic air circuit breaker in a completely metal-enclosed drawout structure. Control and measuring apparatus is mounted on swinging panels integral with the structure.

The circuit breakers are mounted on roll-out carriages, with safety interlocks, which provide easy withdrawal for inspection and maintenance. All circuit breakers of like ampere rating are interchangeable so that spare elements may be substituted to maintain continuous service while regular units undergo maintenance. The entire equipment is built to withstand the extremely high values of short-circuit current encountered in large d-c power systems.

Case of Priority for Invention of Magnetron Strapping Decided

Priority of invention of basic magnetron strapping was awarded on December 4, 1950, by the United States Patent Office to Dr. Percy L. Spencer, Vice-President in charge of the Power Tube Division of the Raytheon Manufacturing Company in Waltham, Mass. This action was based on concession of priority for the United States by Dr. James Sayers of England. It marks the end of an extended interference contest in the United States Patent Office.

The basic idea of tying alternate oscillators in a cavity magnetron to improve mode separation and increase efficiency was first conceived by Doctor Spencer during the early part of 1941. This concept played an important part in making the magnetron a powerful and reliable generator and thus the basic element for countless radars, fire control systems, and other electronic weapons used in World War II. These vital devices are of increasing importance today.

This invention is one of a score of significant contributions Doctor Spencer has made in the field of electronics. His work on the proximity fuse, lamination of magnetrons to permit mass production, and the development of various types of continuously tuned magnetron systems has been recognized by various national citations culminating in the United States Navy's highest civilian award.

Range and Power of Light Microscope Extended by TV

Significant extension of the range, power, and versatility of the light microscope by use of special electronic eyes of the television camera, instead of the human eye, has been developed by scientists of Princeton University and the Radio Corporation of America (RCA) Laboratories Division.

The new technique of televised microscopy, since it enables the interchanging of television camera tubes made sensitive to specific wavelengths of light, gives considerably sharper contrast than heretofore available. The television-microscope combination also has the advantages of making possible the study of many components of living cells normally visible only after killing and staining, and the direct observation of motion of, and within, these cells at high magnifications. Even without the specially sensitized tubes, a high degree of contrast enhancement can be obtained by means of the variable light level controls on the television receiver screen.

Though the RCA televised microscopy equipment has been used primarily for research at Princeton, it has proved convenient for showing specimens to several persons simultaneously in a conference group. It also has been used successfully in large classroom demonstrations.

The experimental installation consists of a laboratory microscope mounted beneath an RCA industrial television camera, which is no larger than a personal 16-millimeter motion picture camera. The televised microscopic scene is transmitted by cable to a standard receiver-monitor placed nearby.

At the heart of the industrial television camera is a remarkably small and sensitive pickup tube—the Vidicon. For microscopy, the Vidicon can be sensitized with materials which make it receptive to a particular narrow band of wavelengths. RCA research engineers are developing tubes which may extend the range of the microscope's vision into the infrared and ultraviolet regions. The microscope also can be equipped with a binocular viewer and a second television camera so that two selective tubes scan the microscopic scene at the same time.

Engineering Societies Library Photoprint Service Revised

To conserve time and the inconvenience of trying to locate material for photoprinting, the Engineering Societies Library has revised this service. For material at the library copies can be supplied as negative prints, white on black, for 40 cents, minimum charge $1.00 per order. Any two facing pages which together measure not over 11 by 14 inches can be taken on one print. Larger material will require one print per page. If the material is not in the library, search will be made on request and if available elsewhere there will be the regular charge of 40 cents a print and an additional charge of $3.00 service fee for locating the article. There will be no charge if the material cannot be located.

Members who order work for their personal use will receive a discount of 20 per cent on the fee for locating the article and a reduction of five cents on each photoprint.

Ten-Foot-Long Tractor Tows Half a Million Pounds

Two Diesel locomotives weighing 500,000 pounds can be towed by an electrically propelled industrial tractor small enough to park in a living room. The demonstration load (shown in the photograph), while a reasonable assignment for the powerful machine, demanded use of only one-sixth of its potential strength, according to the Automatic Transportation Company, Chicago, Ill., which engineered and manufactured it.

Shorter than an automobile and weighing six tons, the tractor can outdo the combined performances of three typical farm tractors. It is able to tow on rails a load of more than 250 times its own weight. To do the equivalent, a man would have to pull some 50,000 pounds.

In explaining the machine's towing ability, the manufacturer says it has ultimate drawbar pull capacity of 10,000 pounds, which enables it to pull as much as 3,000,000 pounds on rails. Despite its great power, the tractor is not large. It is only ten feet long and 64 inches wide and its weight is 12,270 pounds. Its speed unloaded is 21 miles per hour.

Among its outstanding features are 4-wheel drive and 4-wheel steer. The tractor has dual controls, with the two seats facing one another. This permits the driver to change seats and ride facing forward when traveling in either direction, an important safety feature in a vehicle designed to tow such huge loads.

Two Diesel locomotives weighing half a million pounds are towed by an electrically propelled industrial tractor. The tractor, only ten feet long and weighing just six tons, was made by the Automatic Transportation Company, Chicago, Ill.

Metallic Signboard to Act As Communication Link

A metallic signboard, to be erected near Diablo Gorge, a mountain ravine north of Seattle, Wash., will play a vital part in the operation of one of two links comprising the pulse-time modulation (PTM) communication system now being manufactured by Federal Telephone and Radio Corporation for the Department of Lighting of the City of Seattle. Federal is a manufacturing associate of the International Telephone and Telegraph Corporation.

The PTM system will be used for communication purposes between hydroelectric plants, located in a mountainous lake area north of the city, and substations in Seattle's municipally operated power supply system.

Functioning as a passive reflector, the signboard will be strategically located so that microwaves bouncing off its surface will be reflected to the next station, thus overcoming the problem presented by a mountainous barrier to line-of-sight communication between the Diablo Gorge power plant and a plant on Lake Diablo, six miles distant.

New Radiation Detector Announced by General Electric

A new atomic radiation detector to permit direct radiation readings at a glance has been announced by the General Electric Company's Special Products Division. Called a "radiation monitor," the new instrument weighs less than a pound and is about the size of a quart oil can. It is equipped with a self-contained power source, and has neither tubes nor batteries.

According to the engineers of the General
Electric General Engineering and
sulting Laboratory, who developed the
vice, radiation measurements are read
the monitor simply by noting the position
pointer as it moves across a graded s
The speed at which the pointer moves a
the scale is in proportion to the strengt
radiation, and the distance it moves in a g
time indicates the amount of radiatio
which the instrument has been exp
during that time.

The monitor is for use by engine
scientists, doctors, and technicians who
working with or near sources of radiat
and can warn of the presence of radiatio
amounts much less than those permitted
even the most stringent safety regulati
according to the engineers.

This sensitivity, coupled with a
tinuously visible indication, will give warn
of a radiation hazard in an area while th
is still time to avoid excessive expos
This differs from the type of monitor
is read only at intervals, when it may alre
be too late to prevent an overdosage,
engineers said.

Increased Electricity Production Promoted by United Nations E

A major step was taken by governm
legal and technical experts at Gen
Switzerland, in December, 1950, towa
the elimination of legal obstacles to
development of hydroelectric resources
European frontier rivers and lakes
towards simplifying legal and econo
conditions governing the export and imp
of electric power.

These experts, at a meeting called by
Electric Power Committee of the Uni
Nations Economic Commission for Eur
(ECE), undertook a systematic effort
replace, by means of two conventions
model agreement clauses, the welter of va
ing national laws and international ag
ments which now frequently hamper elec
energy trade and development.

They requested the preparation of a mo
agreement to facilitate the developmen
hydroelectric resources of rivers and lake
interest to two or more countries.
model international agreement would incl
fiscal, customs, and payments guaran
whose present absence discourages devel
ment efforts.

The experts in the ECE legal group
envisaged the eventual creation of compa
not under national but under internatio
law, which would be responsible for
construction and exploitation of such hyd
electric resources. This is a new l
conception in electric energy developm
The ECE secretariat was asked to prep
a study on this subject, using such exam
as the airport of Bâle-Mulhouse and
treaty between the United States
Canada on the St. Lawrence waterway.

Man-Made Rain Produced on Demand in Hollywood

Movie sets must have rain when and wh
they want it, and General Electric mo
are being used by the Paramount Stu
in Hollywood on equipment which

uce anything from a cloudburst to a kle over an area of 10 to 36 feet in eter.

give an illusion of rain in motion res, previously it had been necessary ve large pipe systems rigged above the e set with nozzles attached at frequent vals. Now, however, a less expensive more readily controlled system has been oped.

General Electric 1/4-horsepower 1,750- motor which belt-drives an inverted ving manifold is the center of the ity. Coupled to this manifold on sections of pipe are rainheads or ts for the water. The equipment is ected to the water tap through a length ubber hose. Normal tap pressure is , which eliminates the need of a booster m. The motor spins the revolving ifold at approximately 350 rpm and, arying the voltage on the motor and sting the water pressure on the manifold, rea covered and the type of rain can be sted to suit the needs of the script. tional equipments may be added to ase the area covered.

ne rainmakers are hung approximately et above the set in a permanent location ay be slung from a boom for portability for spotting over particular areas of the vhere a storm is required.

even of these rainmakers are now in in the Paramount Studios and more contemplated in the near future.

ndard Value for Resistivity f Copper Announced by IEC

ne International Electrotechnical Com- on (IEC) has announced its decision ne standard value for resistivity of copper. decision was made necessary by a change international to absolute electrical adopted last year in most countries. IEC statement was prepared by Dr. . Crittenden, for many years a member e United States National Committee of Doctor Crittenden has just retired sociate director of the National Bureau tandards. The statement follows:

One of the important early accomplish- ts of the International Electrotechnical mission was the establishment of a dard value for resistivity of copper. was agreed upon in 1913 and was unced in 1914 by IEC Publication *ber 28*, International Standard of Re- nce for Copper (Specification Inter- nal pour le Cuivre-Type Recuit). The e accepted was 1/58-ohm square milli- r per meter, at 20 centigrade, or in nal notation 0.017241. A revised edi- of Publication *Number 28* was issued in , but it retained the same numerical es.

The ohm in this specification was of se the 'international' unit although not amed in the publication. The change ntly made in practically all countries international to absolute electrical raised the question whether the erical value in the copper standard ld be changed. The IEC Committee ction at its meeting in Paris, France, 21, 1950, in accordance with the s expressed by various National Com- ees, decided to take the 'ohm' in the specification as being the absolute ohm; that is, to leave the publication unchanged even though the unit is slightly different.

"As reasons for this decision it was noted that the specification calls for a statement of the conductivity of commercial copper only to 0.1 per cent, whereas the difference between the absolute and the international ohm is only 0.05 per cent. This difference is small in comparison with variations among the different lots of copper. For example, when measurements were being made at the National Bureau of Standards of the United States to provide a basis for a standard value, samples of copper from 14 producers in four countries differed, on the average, from the mean of all by 0.26 per cent, and the value which was accepted as standard in 1913 exceeded the mean resistivity of the 14 lots by more than 0.2 per cent. Consequently, the reduction of 0.05 per cent in the magnitude of the ohm with a corresponding increase in the resistivity to be reported for a given sample really brings the standard value somewhat nearer to the average resistivity of the samples which were investigated."

17-Inch Metal Rectangular Kinescope Announced by RCA

The television industry's first metal rectangular television picture tube has been announced by the tube department of the Radio Corporation of America (RCA). A 17-inch tube, the new kinescope employs the metal-shell construction which was first introduced by RCA as a revolutionary innovation in the 16-inch round metal tube.

The result of extensive development by RCA Tube Department engineers, the new tube was designed to provide a rectangular-shaped kinescope capable of being produced on high-speed automatic machinery.

Inherent advantages of the new metal-shell kinescope are stronger structure and considerably less weight than a similar all-glass tube.

The new 17-inch metal rectangular kinescope utilizes many of the design principles evolved by RCA in its development of the 16-inch round metal tube. Outstanding among these are the large-area, glass-to-metal seals which are used to bond the glass face plate and funnel neck section to the metal shell.

Utilizing the full screen area, the new RCA rectangular picture tube has a picture area 14 5/8 by 11 inches, with slightly curved sides and rounded corners. The new rectangular kinescope is a short wide-angle deflection tube with a maximum over-all length of 19 inches. A second major RCA advance in kinescope design, the development of short wide-angle tubes permitted the housing of big-screen home receivers in compact cabinets little longer than those previously used for 10-inch tubes.

Program for Voluntary Protection of Technical Information

Secretary of Commerce Charles Sawyer has provided a service to help the public guard voluntarily against the harmful release of technical information, even though it is not subject to formal security restrictions The Office of Technical Services (OTS) of the United States Department of Commerce will receive requests for advice as to whether specific technical data should be disclosed, withheld, or given limited distribution. OTS will obtain expert opinions from the interested departments and agencies of the government and inform the inquirer accordingly.

Industrialists, businessmen, scientists, public officials, or private citizens are invited to use this service. There is no compulsion to act upon the advice of the government as the program is entirely a voluntary one.

Requests for advice concerning the release of technical information, together with pertinent manuscripts, plans, or documents, if they are available, should be addressed to:

Office of Technical Services,
United States Department of Commerce,
Washington, 25, D. C.

Your inclosures will be returned with the government's comment as promptly as compatible with the problems of fact and judgment involved.

Military Sets New Minimum for Funds Used for Basic Research

The Department of Defense Research and Development Board (RDB) has approved a new policy formula to guide the Departments of the Army, Navy, and Air Force in their support of basic research.

Under this policy the Department of Defense recognizes the necessity for the support of basic research in the military program and establishes a minimum budget below which this support shall not fall. This budget shall be a fixed percentage of each military Department's average annual total research and development budget for the last five fiscal years.

Stated in round figures, the RDB's new formula provides that the total Department of Defense expenditure for basic research must be at least $30,000,000 in the fiscal year. The policy will be in effect for three years, and will then be reviewed by the board.

Yale University Electric Device Detects Inebriation

An electric device from Chicago, Ill., and a technique developed at Yale University have made it possible for a judge to tell satisfactorily whether or not a man has had too much to drink.

The bad news for drunken drivers, whose inebriation formerly could seldom be established in court, is a portable automatic laboratory called an Alcometer. In eight minutes, and for about 35 cents, it renders its verdict in terms of the percentage of alcohol in the bloodstream.

The standards are: zero to 0.05 per cent, sober; 0.05 to 0.15 per cent, doubtful control of faculties; and from 0.15 per cent up, drunk.

The decision is based on a chemical reaction reassured by a photoelectric cell. For 100-per cent accuracy, and no court accepts less, the electrically operated Alcometer includes a constant-voltage transformer which disciplines the power supply.

The Sola Electric Company, Chicago, Ill., which pioneered in controlled voltage research some 20 years ago, explains that voltage is subject to fluctuation almost as much as some of the subjects for this tester. If higher or lower than it should be, voltage would cause errors in timing, measurement, and recording. If it is controlled it forbids error.

Already in use in some states, the Alcometer has won acceptance by several courts.

The machine's workings are simple. The subject exhales into a tube, and from that point on, the procedure and timing are automatic. Whatever alcohol is in the breath reacts with a chemical, iodine pentoxide, in the Alcometer, producing free iodine. The device then measures the intensity of the color produced by the iodine in a fixed volume of starch and potassium iodide solution.

Two Additions Incorporated by Lear, Inc., to *F-5* Autopilot

William P. Lear, Director of Research and Development and Chairman of the Board of Lear, Inc., has announced two vital features to be incorporated in the Lear *F-5* Autopilot now in quantity production for the United States Air Force. (For more detailed information about the *F-5* Autopilot, see the February issue of *Electrical Engineering*, page 175.) The new *F-5* will offer jet fighter pilots unlimited maneuverability and automatic tracking on targets by coupling radar devices to the computer of the existing *F-5* equipment. These new features, in amplifying the *F-5*'s present ability to fly straight and level automatically and to make automatic approaches to the runway, will add to the safety of the pilot and his airplane under all weather condition, and will greatly enhance the effectiveness of the *F-5* as an offensive and defensive military weapon against surprise atomic bomb attack.

These new devices, coupled with the Lear *F-5* Autopilot and Approach Coupler, will relieve the fighter pilot of nearly all of the physical effort required in his flying. The combination will be an unerring electromechanical copilot capable of controlling the speedy jet planes in every phase of take-off, flight, and landing.

The new components of the *F-5* are designed to retain the "tightness of attitude" so necessary in efficient autopilot-controlled maneuvering and which has been a major problem for engineers. With the incorporation of these new features, the combination will still be the lightest and most compact automatic pilot in production, in keeping with the aviation industry's quest for light, compact equipment.

The *F-5* Autopilot is at present in production at the Grand Rapids, Mich., plant of Lear, Inc., and was developed by them in conjunction with the Air Materiel Command, United States Air Force. It is the first autopilot designated for installation in jet fighter aircraft, and is the first autopilot to successfully fly jet planes.

The new miniature components of the *F-5* Autopilot are research and development projects of Mr. William P. Lear, who was recently awarded the Collier Trophy for the outstanding contribution to the aviation industry in 1950 (*EE, Feb '51, p 174–5*). The citation was given Mr. Lear primarily for research and development work on the Lear *F-5* Autopilot.

Reclamation Tests Save Millions on World's Highest Dam in India

A way of saving $10,000,000 in the cost of what will be the world's highest dam, the proposed 785-foot Kosi Dam on the Kosi River in India, has been worked out by the Bureau of Reclamation at its Denver Engineering Center in tests for the Indian Government. The tests cost little more than half the $30,000 advanced by the Indian Government for the work, and a voucher for the return of the unused portion of the advance has been forwarded by the Bureau for remittance through the Department of State.

The large potential saving emphasizes the contributions made by the United States to the world-wide advancement of water resources development. Bureau of Reclamation operations include the assignment of its experts to foreign lands for technical advice and assistance on engineering problems, tests and laboratory research at Denver, and training courses for young engineers sent to the Center by their Governments.

The Kosi Dam, as planned by the Indian Government for construction in the southeastern corner of Nepal, a few miles from Darjeeling, would be 57 feet higher than Hoover Dam on the Colorado River near Las Vegas, Nev., now the world's highest.

The reservoir impounded by the dam would irrigate 4,000,000 acres of land, an area larger than Connecticut and Rhode Island, which is expected to produce 1,000,000 tons of new food supplies annually to meet the pressing needs of India's expanding population. In addition, elimination of present flood areas by construction of the dam would decrease the incidence of malaria and other diseases in the region.

Unique engineering problems at Kosi are the danger of earthquakes and the unusual silt load of the river. Earthquakes have shaken the dam site on four recorded occasions, yet today engineers accept this
factor not as an obstacle but merely as c
of the elements to be considered in designi
the dam.

Under present plans, after prelimina
work is completed, the Kosi irrigation syst
is expected to be finished within four ye
and the dam itself within 11 years.

New Plastic Battery Separator Made Solely from U.S. Resource

The possibility of shortage in the countr
battery production because of diminishi
supplies of good wood and of natural a
synthetic rubber could be eliminated by
new plastic battery separator, it was a
nounced by The Electric Storage Batte
Company, manufacturer of Exide batteri
Called Pormax, the new plastic separat
is a polyvinyl chloride synthetic and
made solely from raw materials which a
found in abundance within the United Stat

Separators are inserted between t
plates of a battery to separate the positi
plates from the negative plates. Th
should be made from highly porous, ac
resistant, and nonoxidizable materials. P
Orford cedar or Douglas fir wood commor
is used to make separators for automob
batteries. In addition, the higher gra
batteries use rubber or glass separat
because of their better resistance to el
trolyte attack and oxidation. Separa
deterioration due to oxidation is one of
major causes of automobile battery failu
The Pormax separator is porous, nonbritt
and acid-resistant, and it is claimed that
increases battery life.

The 21st Annual Safety Convention a
Exposition. Safety problems of Americ
industry will be discussed at a series of c
ferences to be held April 3–6, 1951. T
sessions will be held at the Hotels Stat
and Governor Clinton, New York, N.
The convention is sponsored by the Grea
New York Safety Council with the aid
62 national and local co-operating agenc
of which the AIEE is one. For furt
information write to Mr. Benjamin Kenc
at the Greater New York Safety Council,
East 42 Street, New York 17, N. Y.

LETTERS TO THE EDITO

INSTITUTE members and subscribers are invited to contribute to these columns expressions of opinion dealing with published articles, technical papers, or other subjects of general professional interest. While endeavoring to publish as many letters as possible, Electrical Engineering reserves the right to publish them in whole or in part or to reject them entirely. Statements in letters are expressly understood to be made by the writers. Publication h
in no wise constitutes endorsement or recogni
by the AIEE. All letters submitted for publica
should be typewritten, double-spaced, not car
copies. Any illustrations should be submitted
duplicate, one copy an inked drawing with
lettering, the other lettered. Captions should
supplied for all illustrations.

Measuring Speed of Light

To the Editor:

Your article in the January *Electrical Engineering* (pages 88–89) on the experiments in measuring the speed of light was very interesting to me. The physicists at St
ford have certainly made a contribution
the world's knowledge by their car
work. Even though I am quite a layn
on this subject, I am presuming to mak
few suggestions for what they are worth

ctor Einstein's postulate that light
s are bent by gravitational fields has
proved quite recently. The red shift
l by astronomers, and attributed to an
nding universe by some, also could be
ed by enormous gravitational effects on
traveling over cosmic distances; the
tant could be a shift in the spectrum.
am assuming that most of the experi-
s to determine the speed of light, from
or Michelson down to the present time,
been near sea level and subject to the
gravitational field. Perhaps some of
errors in loran determinations have
due to a phase of the moon and its
itational effect. Our present knowledge
avitation leaves us with the fact that it
intangible as time and yet it is tied in
the speed of light and all other energy
omena.
would suggest that the researchers at
ford move their equipment to higher
ides, possibly Denver or higher, or
aps make identical calculations at peri-
n and aphelion in our trip around the
Carefully measured distances at sea
and then in high mountains could be
ked by radar using a calibrated oscillo-
e to show the effect produced by a
ge in the gravitational field.
he article you presented was very in-
ting and I was constrained to offer a
suggestions.

P. C. POGUE (A '47)

(Alabama Power Company, Birmingham, Ala.)

rection on Nomenclature

he Editor:

connection with my article, "The Need
Equipment to Test Aircraft Electric
ors" (*EE, Jan '51, pp 41–6*), I have
ived a modification in nomenclature
a reader who believes that a correction
ld be published.
igure 6, showing a standard "lightweight"
y impact machine, and the accompany-
reference in the text appearing in
graph 4, column 1, page 45, do not
tly describe this shock-testing device.
ore correct name for this machine is a
-impact machine for electronic devices.
ording to personnel at the Naval Re-
ch Laboratory (NRL), the first machine
built by that group; the second was
t by Armour Institute from NRL
vings. Still later machines were built
Taft-Pierce Company (Woonsocket, R.
rom NRL drawings and were distributed
ut the country in an effort to standardize
k-testing requirements for electronic
ces.

I. E. ROSS (M '44)

(General Electric Company, Fort Wayne, Ind.)

EW BOOKS • • • • •

**following new books are among those recently
ved at the Engineering Societies Library. Un-
otherwise specified, books listed have been pre-
ed by the publishers. The Institute assumes no
onsibility for statements made in the following
naries, information for which is taken from the
ces of the books in question.**

A.S.T.M. STANDARDS ON PETROLEUM PRODUCTS AND LUBRICANTS, prepared by Committee D-2; Methods of Testing, Specifications, Definitions, Charts, and Tables. American Society for Testing Materials, 1916 Race Street, Philadelphia 3, Pa., November 1950. 764 pages, illustrations, diagrams, charts, tables, 9 by 6 inches, paper, $5.50; cloth, $6.15. This latest compilation of A.S.T.M. standards on petroleum products and lubricants contains 112 test methods, 8 specifications, 3 lists of definitions, and 2 tentative recommended practices. It covers crude petroleum, motor and aviation fuels, light hydrocarbons, tractor and diesel fuels, hydrocarbon liquids, kerosene and illuminating oils, lubricating oils, turbine oils, electrical insulating oils, thermometers, plant spray oils and petroleum sulfonates, greases, petrolatums and paraffin waxes. Methods of test for rating fuels also are included.

ADVENTURE INTO THE UNKNOWN. By L. A. Hawkins. William Morrow and Company, New York, N. Y., 1950. 150 pages, illustrations, $9^{1}/_{2}$ by $6^{1}/_{4}$ inches, linen, $3.50. This book surveys the first 50 years of work done at the General Electric Research Laboratory. It describes the character of the laboratory, its methods and objectives, the diversity, range, and significance of its projects, and the personal characteristics of some of its leaders. Some of the individual accomplishments discussed are Dr. Irving Langmuir's work with incandescent lamps, early vacuum tubes, and weather research; Dr. Albert Hall's studies in electronics; and Dr. Saul Dushman's researches into high vacuum.

AMA HANDBOOK OF WAGE AND SALARY ADMINISTRATION, Tested Compensation Methods for Factory, Office and Managerial Personnel. Edited by M. J. Dooher and V. Marquis. American Management Association, 330 West 42nd Street, New York 18, N. Y., 1950. 412 pages, diagrams, charts, tables, $9^{1}/_{4}$ by 6 inches, linen, $7.50. Integrating material published by the Association, this manual is a complete survey of the principles and techniques of wage and salary administration and of management's experience in their day-to-day application. It also contains the new AMA research material on wage surveys, union contract provisions covering office salary administration, job evaluation forms, and a bibliography. A model manual used by a company to explain its wage program to employees is reproduced in its entirety as an appendix.

AUTOMOTIVE ELECTRICAL EQUIPMENT, Its Operation and Maintenance. By W. H. Crouse. Second Edition. McGraw-Hill Book Company, New York, N. Y.; Toronto, Ontario, Canada; London, England, 1950. 330 pages, illustrations, diagrams, charts, tables, $9^{1}/_{4}$ by 6 inches, linen, $4.00. Written in simple, nontechnical language, this book covers the practical operation and the theory of operation and maintenance of the electric systems in busses, trucks, and automobiles. It discusses storage batteries, generators, regulators, cranking motors, ignition systems, switches, lights, heaters, and radios. The emphasis is on practical how-to-do-it procedures. A special section deals with the construction and operation of the gasoline engine.

(THE) CHEMICAL FORMULARY, Volume IX. Edited by H. Bennett. Chemical Publishing Company, Brooklyn, N. Y., 1951. 648 pages, tables, $8^{1}/_{2}$ by $5^{1}/_{2}$ inches, linen, $7.00. This volume of the Chemical Formulary contains a collection of new, up-to-date formulae for a wide variety of products. Only the introductory material which is repeated in all volumes is retained. The list of chemicals and their suppliers has been enlarged with new trade-mark chemicals.

ECONOMICS OF FUEL GAS FROM COAL. By Battelle Memorial Institute; J. F. Foster and R. J. Lund, Editors for Bituminous Coal Research. McGraw-Hill Book Company, New York, N. Y.; Toronto, Ontario, Canada; London, England, 1950. 289 pages, diagrams, charts, tables, $9^{1}/_{4}$ by 6 inches, linen, $5.00. This book contains the results of a survey undertaken by Battelle Memorial Institute for Bituminous Coal Research, Inc. Divided into two main parts, the first deals with the technical aspects of fuel-gas production and includes available data on operating costs, maintenance, and investment cost of gasification processes, and on research. The second part assembles data on the costs of transporting various fuels and discusses supplies, demand, and past prices. From these and other data, future price trends for each fuel are predicted.

ELECTRONS AND HOLES IN SEMICONDUCTORS WITH APPLICATIONS TO TRANSISTOR ELECTRONICS. By W. Shockley. D. Van Nostrand Company, New York, N. Y.; Toronto, Ontario, Canada; London, England, 1950. 558 pages, illustrations, diagrams, charts, tables, $9^{1}/_{4}$ by 6 inches, linen, $9.75. Written for electrical engineers, physicists, designers, and students, this book provides a practical theoretical and working knowledge of the properties and uses of transistor devices. Part I contains only the simplest theoretical material needed to establish a clear understanding of the operation of transistor devices and for elementary design considerations, Part II presents the reasoning and results of Part III in pictorial and descriptive terms, and Part III explains how fundamental quantum theory leads to the abstractions of the positive hole and its negative counterpart, the excess electron. Part III also contains an introduction to statistical mechanics and other topics applicable to the theory of electronic conduction in crystals.

FUNDAMENTALS OF QUANTUM MECHANICS By E. Persico, translated and edited by G. M. Temmer. Prentice-Hall, Inc., New York, N. Y., 1950. 484 pages, diagrams, charts, tables, $8^{3}/_{4}$ by $5^{1}/_{2}$ inches, linen, $8.00. In this book are presented the fundamental laws and principles of quantum mechanics, together with some applications. The first part provides a historical, over-all view of the evolution of quantum mechanics using an intuitive and elementary approach. The second part, preceded by a mathematical introduction, considers the principles of the wave mechanics of a particle. In the third and last part, the transformation theory is developed, more advanced mathematical methods are used, and applications are considered.

GERMAN-ENGLISH TECHNICAL AND ENGINEERING DICTIONARY. By L. De Vries. McGraw-Hill Book Company, New York, N. Y.; Toronto, Ontario, Canada; London, England, 1950. 928 pages, $9^{1}/_{4}$ by 6 inches, cloth, $20.00. Covering all fields of engineering and technology, this new book contains more than 125,000 entries, including many new words taken from glossaries compiled by various research workers and translators for their own use, now available in book form for the first time. There is a 36-page alphabetical list of German abbreviations with their English equivalents at the end of the volume.

TECHNISCHE LÄRMABWEHR. By W. Zeller. Alfred Kröner Verlag, Stuttgart, Germany, 1950. 328 pages, illustrations, diagrams, charts, tables, $9^{1}/_{4}$ by 6 inches, linen, 28 D.M. This handbook is concerned with the theory and practice of noise prevention. Following a consideration of fundamental principles, there is a detailed discussion of practical applications in cases of machinery construction, industrial plants and shops, and noise from traffic. The materials, economics, and use of sound-proofing in homes, offices, hospitals, hotels, and laboratories also are treated.

TRAVELING-WAVE TUBES. By J. R. Pierce. D. Van Nostrand Company, Toronto, Ontario, Canada; New York, N. Y.; London, England, 1950. 260 pages, diagrams, charts, tables, $9^{1}/_{4}$ by 6 inches, linen, $4.50. This book presents the theoretical material needed by those who want to know about, to design, or to do research on traveling-wave tubes. It covers the radio-frequency aspects of the electronic behavior of the tube and its internal circuit behavior. There are brief discussions of the magnetron and double-stream amplifiers. Experimental material is included to illustrate the range of theoretical treatments possible with the traveling-wave tube.

TREASURY OF EARLY AMERICAN AUTOMOBILES, 1877–1925. By F. Clymer. McGraw-Hill Book Company, New York, N. Y.; London, England; Toronto, Ontario, Canada, 1950. 213 pages, illustrations, diagrams, 11 by $8^{1}/_{2}$ inches, stiff cardboard, $5.00. This collection of photographs, text, advertisements, songs, cartoons, and memories of the early automobiles and their manufacturers covers the period from Selden's "horseless carriage" (1877) to a latter-day version of the Model T (1925). A list of approximately 2,200 makes of cars once manufactured in the United States is appended.

WINDING ALTERNATING-CURRENT MACHINES. By M. Liwschitz-Garik, assisted by C. Gentilini. D. Van Nostrand Company, Toronto, Ontario, Canada; New York, N. Y.; London, England, 1950. 766 pages, illustrations, diagrams, charts, tables, $9^{1}/_{4}$ by 6 inches, linen, $8.50. Written for winders, repairmen, and designers, this book serves as a handbook for all types of windings used on a-c machines. Each chapter deals with a different type of winding covering both lap and wave windings, balanced and unbalanced windings, and integral-slot and fractional-slot windings. It also includes data on insulation and many handy reference tables.

Library Services

ENGINEERING Societies Library books may be borrowed by mail by AIEE members for a small handling charge. The library also prepares bibliographies, maintains search and photostat services, and can provide microfilm copies of any item in its collection. Address inquiries to Ralph H. Phelps, Director, Engineering Societies Library, 29 West 39th St., New York 18, N. Y.

HOW TO CHART TIMESTUDY DATA. By P. Carroll. McGraw-Hill Book Company, New York, N. Y.; Toronto, Ontario, Canada; London, England, 1950. 323 pages, diagrams, charts, tables, $9^{1}/_{4}$ by 6 inches, cloth, $5.00. Of value to industrial engineers and shop executives, this book deals with the fundamentals and methods of charting timestudy data. Following a discussion of incentives and the cost of timestudy, the standard data method is considered. Curve drawing, alignment charts, timestudy equations, multiple curves, preferred numbers, and various methods of charting timestudy data then are considered.

(THE) IDENTIFICATION OF MOLECULAR SPECTRA. By R. W. B. Pearse and A. G. Gaydon. Second Edition Revised. John Wiley and Sons, New York, N. Y., 1950. 276 pages, illustrations, charts, tables, 11 by $7^{1}/_{2}$ inches, linen, $8.50. This book is designed to help the scientist make accurate identifications of molecular spectra in the wavelength region from 10,000 angstrom units to 2,000 angstrom units. It contains photographs of band systems, tables of wavelengths, suggestions for using the tables, and general information about band spectra. The first part lists the strongest heads of the better-known band systems of each molecule. The second and larger part includes lists of band heads for each system of each molecule.

INTRODUCTION TO THE CALCULUS OF VARIATIONS. By C. Fox. Oxford University Press, New York, N. Y.; Geoffrey Cumberlege, London, England, 1950. 271 pages, diagrams, tables, 9 by $5^{1}/_{2}$ inches, cloth, $4.50. Covering principles and techniques, the first two chapters of this new text deal with the first and second variation of an integral. The remainder of the book includes a study of isoperimetrical problems, Hamilton's principle and an account of its application to the special theory of relativity, the principle of least action, approximation methods with applications to problems of elasticity, and an account of the Weierstrassian theory of strong variations based upon the work of Hilbert. A knowledge of partial differentiation and differential equations is assumed.

LAPLACE TRANSFORMATION, THEORY AND ENGINEERING APPLICATIONS. By W. T. Thomson. Prentice-Hall, New York, N. Y., 1950. 230 pages, diagrams, charts, tables, $8^{3}/_{4}$ by $5^{3}/_{4}$ inches, linen, $5.00. Following introductory material, the properties and dynamical and structural applications of the Laplace transformation are discussed. The theory of complex variables is reviewed to aid in the understanding of applications involving partial differential equations and difference equations. A variety of such applications, including the field of closed-loop systems, are considered. The closing chapter discusses two types of mechanical-electrical analogies frequently used in analysis.

MAN THE MAKER, A HISTORY OF TECHNOLOGY AND ENGINEERING. By R. J. Forbes. Henry Schuman, Inc., 20 East 70th Street, New York, N. Y., 1950. 355 pages, illustrations, woodcuts, diagrams, maps, $8^{1}/_{2}$ by $5^{1}/_{2}$ inches, linen, $4.00. This book explains the development of modern technical achievements as an aspect of the broader history of civilization and culture. It discusses the discoveries and inventions of prehistory, the ancient East, the Greeks and Romans, the Arabs, the Middle Ages, the 16th and 17th centuries, the Industrial Revolution, and the Modern Era. In each case, the close relationship between pure science and engineering and technology is indicated, and the social and economic factors involved in man's conquest of nature are stressed.

MICRO-WAVE MEASUREMENTS. By H. M. Barlow and A. L. Cullen. The Macmillan Company, New York, N. Y.; Constable and Company, London, England, 1950. 399 pages, diagrams, charts, tables, $8^{3}/_{4}$ by $5^{1}/_{2}$ inches, linen, $6.00. Designed for the use of communication engineers, this book is concerned with the presentation of techniques of microwave measurement which have wide application. Special attention is given to measurements of the effects of discontinuities and disturbances on the propagation of guided waves. Emphasis is on principles of operation rather than on details of apparatus. Typical experimental observations are included in some cases as an aid to fuller understanding. The rationalized meter-kilogram-second practical system of units is used.

SAFETY IN ELECTRIC AND GAS WELDING AND CUTTING OPERATIONS (American Standard *Z49.1–1950*). American Welding Society, 29 West 39th Street, New York 18, N. Y., 1950. 42 pages, tables, 9 by 6 inches, paper, $0.50. This standard covers regulations for the safe installation and operation of welding equipment for arc, gas, and resistance welding processes. Provisions are included for fire prevention and protection in regularly assigned welding areas and in other locations as well. The protection of personnel is treated from the standpoint of the welder, for whom eye protection and clothing requirements, health protection, and so forth, are prescribed, and from the standpoint of other workers in areas adjacent to welding operations. Precautions are specified for the welding of materials which may give off toxic fumes and for welding in confined areas.

STATIC AND DYNAMIC ELECTRICITY. By W. R. Smythe. Second Edition. McGraw-Hill Book Company, New York, N. Y.; Toronto, Ontario, Canada; London, England, 1950. 616 pages, diagrams, charts, tables, $9^{1}/_{4}$ by 6 inches, cloth, $8.50. Written for the experimental research engineer and physicist, this graduate text considers methods used in the application of the principles of electricity and magnetism to the solution of actual electrical problems, particularly of nonroutine types. Changes in this second edition include the use of rationalized meter-kilogram-second units, modernized nomenclature, many new theorems with their derivations, 40 new electrostatic problems, a simplification of vector-potential applications to magnetostatics and electromagnetic waves, new material on electromagnetic waves and eddy currents, and a full treatment of boundary conditions encountered in microwave work.

TABLES FOR CONVERSION OF X-RAY DIFFRACTION ANGLES TO INTERPLANAR SPACING (National Bureau of Standards, Applied Mathematics Series 10). United States Government Printing Office, 1950; for sale by Superintendent of Documents, United States Government Printing Office, Washington 25, D. C. 159 pages, tables, $10^{1}/_{2}$ by 8 inches, cloth, $1.75. This book contains tables which give spacing values d in angstrom units corresponding to the angles θ which are usually measured when diffraction patterns are used for chemical identification and crystal structure determination. The first six tables give the spacing values for the angles θ from 0 degrees to 90 degrees at intervals of 0.01 degree. These tables were calculated by using the $K\alpha_1$ wave lengths for X-ray targets of molybdenum, copper, nickel, cobalt, iron, and chromium. The last two tables contain a rearrangement of the data for copper and iron.

PAMPHLETS ● ● ● ● ●

The following recently issued pamphlets may be of interest to readers of "Electrical Engineering." All inquiries should be addressed to the issuers.

Bibliography on Management of Construction Jobs. This is a compilation of 52 selected references to books and periodical articles which deal with construction job planning, work scheduling, cost, organization, preparation of material-requirement charts, material-delivery time scheduling, job progress records, time studies, and material and equipment control. Contracting procedures on various kinds of contracting and building jobs such as small- and large-scale housing, office and factory building, and tunnel, highway, and d
construction also are dealt with. Availa
at $2.00 per copy. This ESL Bibliograp
Number 8 may be purchased from t
Engineering Societies Library, 33 W
39th Street, New York 18, N. Y.

The Story of Surface Coatings Based
Vinylite Resins. This booklet descri
the variety of surfaces which can be coat
including metal, paper, cloth, mason
brick, concrete, and wood, and discus
the various techniques of application
which surface coatings based on resins a
suitable. The booklet also describes t
application of coatings for land, sea, a
air transportation, for dairy equipme
packaging materials, and other fields wh
destructive forces such as weather, abrasi
moisture, chemical attack, and rust are
work. Illustrated. Available upon requ
from the Bakelite Company, Departme
1503, 300 Madison Avenue, New York
N. Y.

Battery Additives. This circular conta
descriptions of typical lead-acid stora
batteries, and by means of tables and grap
describes different properties of batter
such as ampere-hour capacity, speci
gravity, cell temperature, and water c
sumption, and the effect of additives
these properties. 30 pages. Available
15 cents per copy. Requests should
addressed: National Bureau of Standar
Circular 504, Government Printing Offi
Washington 25, D. C.

Contemporary Lighting in Modern a
Traditional Interiors. The booklet
scribes a wide variety of lighting ide
combining adequate home lighting with go
decoration techniques. There are 130 larg
scale illustrations showing actual interi
and sketches of construction details for ide
in the use of light and color in differe
home surroundings. Both installed lighti
fixtures and portable lamps are shown
use. This report provides a working gu
for home builders, contractors, inter
designers, homemakers, and anyone who
concerned with residential lighting a
decoration problems. Single copies
available at $1.00 each; quantity pri
upon request from Publications Offi
Illuminating Engineering Society, 51 Ma
son Avenue, New York 10, N. Y.

Government Administration of the Cop
Industry. This is a second edition of
booklet reviewing the formation of the W
Production Board during World War
The contents apply equally to other strate
materials, especially steel and aluminu
It is believed that this booklet may
helpful to those in both government
industry again involved in formulat
policies to assure adequate production
strategic materials. The booklet was writ
by Mr. J. W. Douglas, President of Repu
Foil and Metal Mills, who served as assist
of the Copper Division of the War Product
Board during the last war. Available
$1.00 per copy from Mr. J. W. Doug
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Triangle Street, Danbury, Conn.

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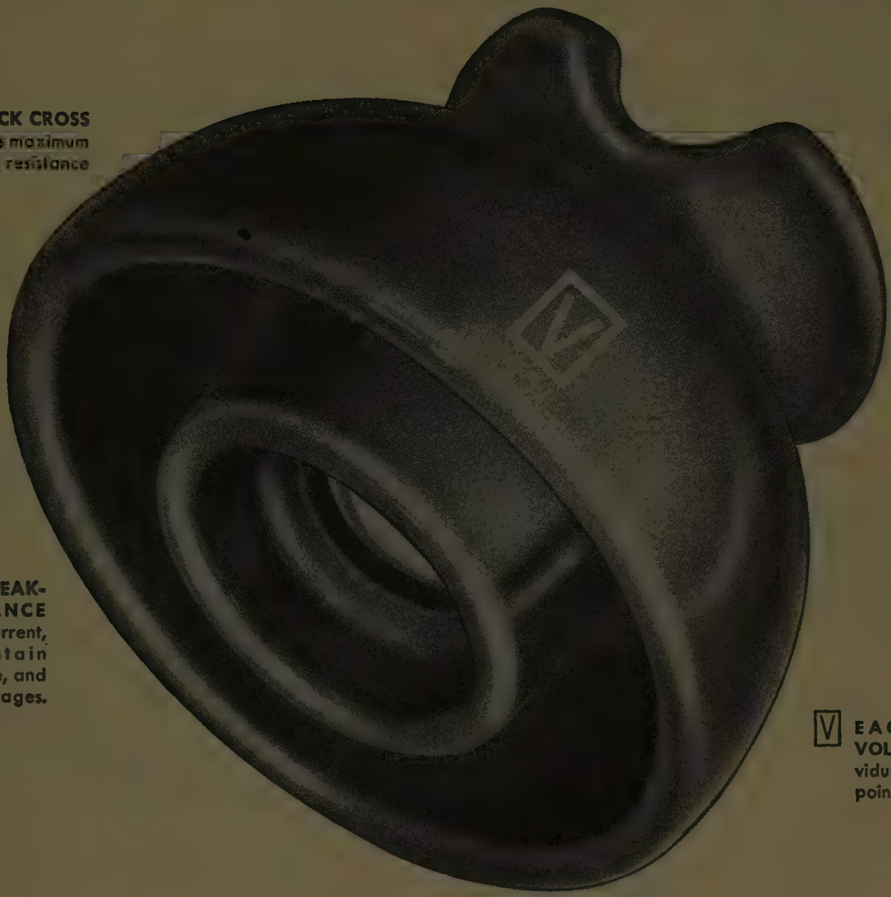

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INDUSTRIAL NOTES ....

Allis-Chalmers Subsidiary Acquires Canadian Firm. The purchase of all the physical assets of Canadian Allis-Chalmers, Limited, by a new wholly owned subsidiary of Allis-Chalmers Manufacturing Company has been announced by the parent concern. The new subsidiary is known as Canadian Allis-Chalmers (1951) Limited. M. C. Lowe, formerly Vice-President of Canadian Allis-Chalmers, Limited, has been named President of the new subsidiary. The plant, located at Lachine, Quebec, will continue the production of heavy machinery for the Canadian market. Allis-Chalmers has also announced the appointment of Frank R. Hunter as manager of a new branch office of the company's general machinery division in Wichita, Kans.

Johns-Manville Realigns Executive Personnel. A new President, Vice-Chairman, three Vice-Presidents, and three new directors have been elected in a regrouping of executive responsibilities in the Johns-Manville Corporation. The realignment of executive personnel to meet new conditions of manufacturing in a defense economy comes at a time when the company has achieved a record year of net sales of more than $200,000,000. A new planning board has been established to seek major opportunities to expand business, analyze overall company policy, and co-ordinate activities of the various divisions of Johns-Manville. Clifford F. Rassweiler has been made Vice-Chairman of the board, and he has been delegated full responsibility for organization and direction of the planning board. He will also continue as Vice-President for research and development. The company's new President is L. M. Cassidy, who succeeds R. W. Lea, now retired. Mr. Cassidy also becomes a Director and operations officer of the corporation. A. R. Fisher, Vice-President for production and general manager of the company's asbestos fibre division, has been elected a Director, and will report directly to the Chairman in carrying out his responsibilities for the mining of and exploration for asbestos fibre. The three new Vice-Presidents appointed by the company are J. A. O'Brien, Harold R. Berlin, and A. S. Elsenbast.

Automatic Switch Changes Officers. The Board of Directors of the Automatic Switch Company has elected the following new officers: W. F. Hurlburt, Sr., Chairman of the Board; W. F. Hurlburt, Jr., President; H. V. Darrin, Vice-President and Secretary; and David M. Darrin, Vice-President and Treasurer.

National Electric Coil Promotion. Joseph S. Cowan has been made manager of government business for the National Electric Products Corporation.

Youmans Made Vice-President of Okonite. The Okonite Company has announced the appointment of E. D. Youmans as Vice-President in charge of manufacturing and research. Mr. Youmans replaces D. R. Stevens, Executive Vice-President, who is retiring.

Armstrong-Whitworth Purchased by American Firm. The Independent Pneumatic Tool Company, Aurora, Ill., has purchased Armstrong-Whitworth and Company, Pneumatic Tools, Limited, of England.

Admiral Halsey Made President of International Telecommunication Laboratories. Fleet Admiral William F. Halsey, Jr., (USN Retired) has been elected President of International Telecommunication Laboratories, Inc., an associate of the International Telephone and Telegraph Corporation.

Simplex Appoints New Chicago Manager. The Simplex Wire and Cable Company has announced the retirement of J. N. Macalister, manager of its Chicago district office, and the appointment of W. H. Davis to succeed him.

United States Steel Appointments. The United States Steel Corporation has announced the following appointments: Robert C. Tyson, comptroller, has been elected a Vice-President; John H. Elliott has been made general manager of manufacturing; William C. Oberg, manufacturing consultant; David A. Challis, Jr., has been named assistant general manager of sales; and Charles W. Baldwin has been named director, and John W. Clinton assistant director, coal chemical sales division, Commercial Department.

American Steel and Wire Appointment. Alan F. Dill has been promoted to the post of defense regulations co-ordinator for the American Steel and Wire Company, a subsidiary of United States Steel.

Westinghouse News. The Westinghouse Electric Corporation has purchased a 70-acre tract in Western Alabama for construction of a new light-bulb plant. The Company has also announced the following appointments: W. G. Miller has been named manager of manufacturing of the motor and control division, Buffalo, N. Y.; Roger W. Doering has been made supervisor of plant engineering for the Westinghouse lamp division, Bloomfield, N. J.; W. L. Budge has been appointed manager of the atomic power division facilities in Idaho; Dr. E. A. Lederer has returned to Westinghouse as manager of engineering for the electronic tube division, Bloomfield, N. J.; W. P. L'Hommedieu has been named assistant Pacific Coast district manager; Bruce D. Henderson has been made general purchasing agent; Wesley H. Lees has been appointed general traffic manager; and L. D. Rigdon has been made assistant to the Vice-President in charge of manufacturing.

(*Continued on page 26A*)

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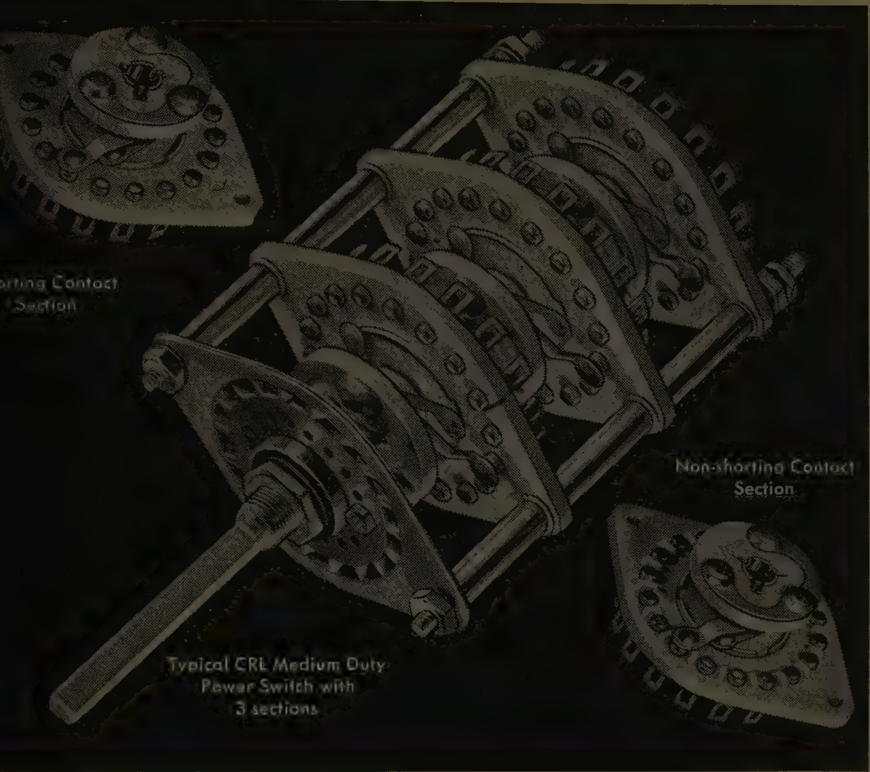
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No. rting	Part No. Non-Shorting	Total Poles	Positions	Total Sections	Poles per Section
000	JV9001	1	2-17	1	1
002	JV9003	3	2- 5	1	3
004	JV9005	2	2-17	2	1
006	JV9007	6	2- 5	2	3
008	JV9009	3	2-17	3	1
010	JV9011	9	2- 5	3	3
012	JV9013	4	2-17	4	1
014	JV9015	12	2- 5	4	3
016	JV9017	5	2-17	5	1
018	JV9019	15	2- 5	5	3
020	JV9021	6	2-17	6	1

nished with adjustable stop to limit rotation to desired number of positions

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Switches are designed for R.F. or 7½ amp., 110-115 V. application. The combination of rugged construction — coin silver contacts plus the high insulation resistance of Grade L5 Steatite means long-term, trouble free performance.

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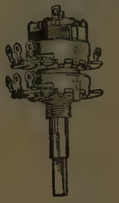

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SEAL RINGS • TROLLEY and PANTOGRAPH SHOES, etc.

(Continued from page 18A)

Dr. Bowie to Direct Engineering
Sylvania. Dr. R. M. Bowie has b
appointed Director of Engineering
Sylvania Electric Products, Inc., and Jo
T. Burdick has been made director
midwest sales for the company.

Bendix Leases Pimlico Airport. T
Bendix radio division of the Bendix Av
tion Corporation has leased 40 acres
land, two airplane hangars, and buildi
at Pimlico Airport in Baltimore, M
The buildings will be remodeled for
as laboratories and classrooms where
Force ground personnel will be train
to maintain military electronic equipme

G. M. Ruoff Joins Porcelain Produ
Inc. G. M. Ruoff, formerly with Loc
Inc., has joined the staff of Porcel
Products, Inc., as Vice-President a
general manager of their high-volt
division. Mr. Ruoff is also a director
the company.

International Rectifier Enlarges Pla
In order to meet increased product
requirements, the International Recti
Corporation has added a second story
its plant located at 6809 South Victo
Avenue, Los Angeles 43, Calif.

Locke Promotion. Hubert M. C
michael has been named regional mana
for Locke, Inc., at Atlanta, Ga.

Cannon Sales Engineering Appointme
William Cranford has been appointed
the sales engineering staff of the Cann
Electric Development Company.

RCA Victor News. To meet the co
pany's requirements for experienced en
neering personnel, the RCA Victor D
sion of the Radio Corporation of Amer
has established a new Employment D
sion. Robert E. McQuiston has b
named manager. The company also
announced the appointments of Theod
A. Smith as assistant general manager
the RCA Engineering Products Depa
ment; Lawrence LeKashman as mana
of the advertising and sales promot
section, Tube Department; and L.
Battaglia as manager of the renewal s
field force, Tube Department.

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Selenium Rectifier Cartridges Up to
Kv. High-voltage selenium rectifier c
tridges with voltage ratings up to 25,
volts per cartridge and current ratings
to 75 milliamperes have been announ
by the International Rectifier Corporat
These rectifier cartridges utilize
different selenium cell sizes varying f
1/8 inch in diameter up to one inch
diameter with corresponding current
ings varying from 1.5 milliamperes u

(Continued on page 28A)

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VHETHER YOU NEED an 11.4 kva regulator on a small feeder—or the biggest 00 kva three phase unit, the entire Allis-almers regulator line provides these same lity features:

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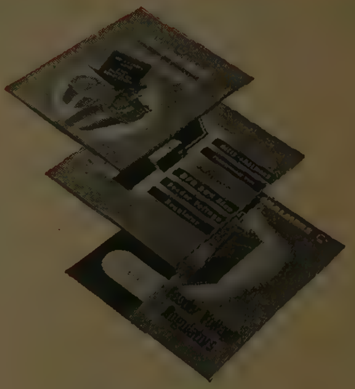
JFR — Single phase regulator, 11.4 kva, 7620 v, 15 amp.

DFR — Single phase regulator, to 250 kva, 6900 v.

AFR — Three phase regulator, sizes through 2500 kva, 69 kv.



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Among other useful features, this practical book

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- Presents charts indicating nature of design characteristics necessary to obtain desirable steady-state and transient responses.

CHAPTERS:

The Automatic Control Problem
Manipulation of Complex Numbers
Solution of Linear Differential Equations
Laplace Transforms for the Solution of Linear Differential Equations
Steady-state Operation with Sinusoidal Driving Functions
Methods of Determining System Stability
Typical Control Elements and Their Transfer Functions
Types of Servomechanisms and Control Systems
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(*Continued from page 26A*)

75 milliamperes. They have been designed to meet rigid humidity, altitude vibration, and shock specifications, and can be operated over the temperature range of −55 degrees centigrade to 100 degrees centigrade. Further information is available from the International Rectifier Corporation, 6809 South Victoria Avenue, Los Angeles 43, Calif.

Air Compressor. Designed for positive operation at 50,000-foot altitude, the Lear-Romec model *RG-8160-1* air compressor is equipped with an a-c motor rated 1/5 horsepower, 115 volts, 400 cycles, single phase, four amperes, 7,200 rpm. The minimum capacity at 50,000 feet is 80 cubic inches per minute while maintaining 32 inches of mercury absolute pressure. Sea level capacity is 1,750 cubic inches of free air per minute. Principal use of this compressor is the pressurizing of radar installations in aircraft to maintain an atmosphere of dry oil-free air. Service life is 1,000 hours with no decrease in performance. Sliding blades of the rotary pump are self-lubricated Graphitar to assure positive starting and pumping at −87 degrees Fahrenheit. R. S. Atkinson, Lear, Inc., Romec Division, Elyria, Ohio., will supply further information.

Cutter Grinder. An inexpensive precision cutter grinder for sharpening engraving cutters has been made available by New Hermes, Inc., 13 University Place, New York, N. Y. A feature of this sharpening device is the index unit on the spindle which allows the operator to grind any desired cutting profile with proper angles and clearance. Two, three, and four fluted cutters also can be ground and sharpened by using the attached indexing plate. The grinder has an adjustable clamp head for radius grinding. The rotating base of the cutter head has a 140-degree graduation. The cutter feed dial has graduations of 1/1,000 inch and is powered by a 1/6-horsepower universal motor rated 115 volts, with a speed of 6,000 rpm. Further details may be obtained from the company.

Signaling Equipment. A new type of signaling equipment designed to adapt older types of carrier systems to dial operation has been developed by Federal Telephone and Radio Corporation. It has been engineered to meet present-day requirements for local, toll, and long-distance dialing. Designated as Federal's *904* signaling equipment, this new development permits dialing with full hook-switch supervision over existing long-, medium-, or short-haul carrier telephone channels; over 4-wire physical circuits; and over microwave radio-link channels. Principal features are a full-channel frequency bandwidth during conversation; transmission of audible dial, busy, and ringback tones; dial speeds up to 14 pulses per second; dial-pulse ratio control for dialing accuracy; and full hook-switch supervision to obtain flashing busy and other signals. Type *904* signaling equipment may be connected directly to dialing

(*Continued on page 34A*)

LIGHTNING REFERENCE BIBLIOGRAPHY 1936–1949

Prepared by the AIEE Lightning and Insulator Subcommittee, this bibliography, S-37, contains 754 separate references on lightning and related topics published from January 1, 1936, to December 31, 1949, in most of the better known English, French, and German journals on electrical engineering or physics.

For easy reference, there is a Subject Section, subdivided into 18 classifications, and an Author Section, which contains a list of about 550 authors. Price: $0.70 ($0.35 to AIEE members).

Available from the Order Department, AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS, 33 West 39th Street, New York, N. Y.

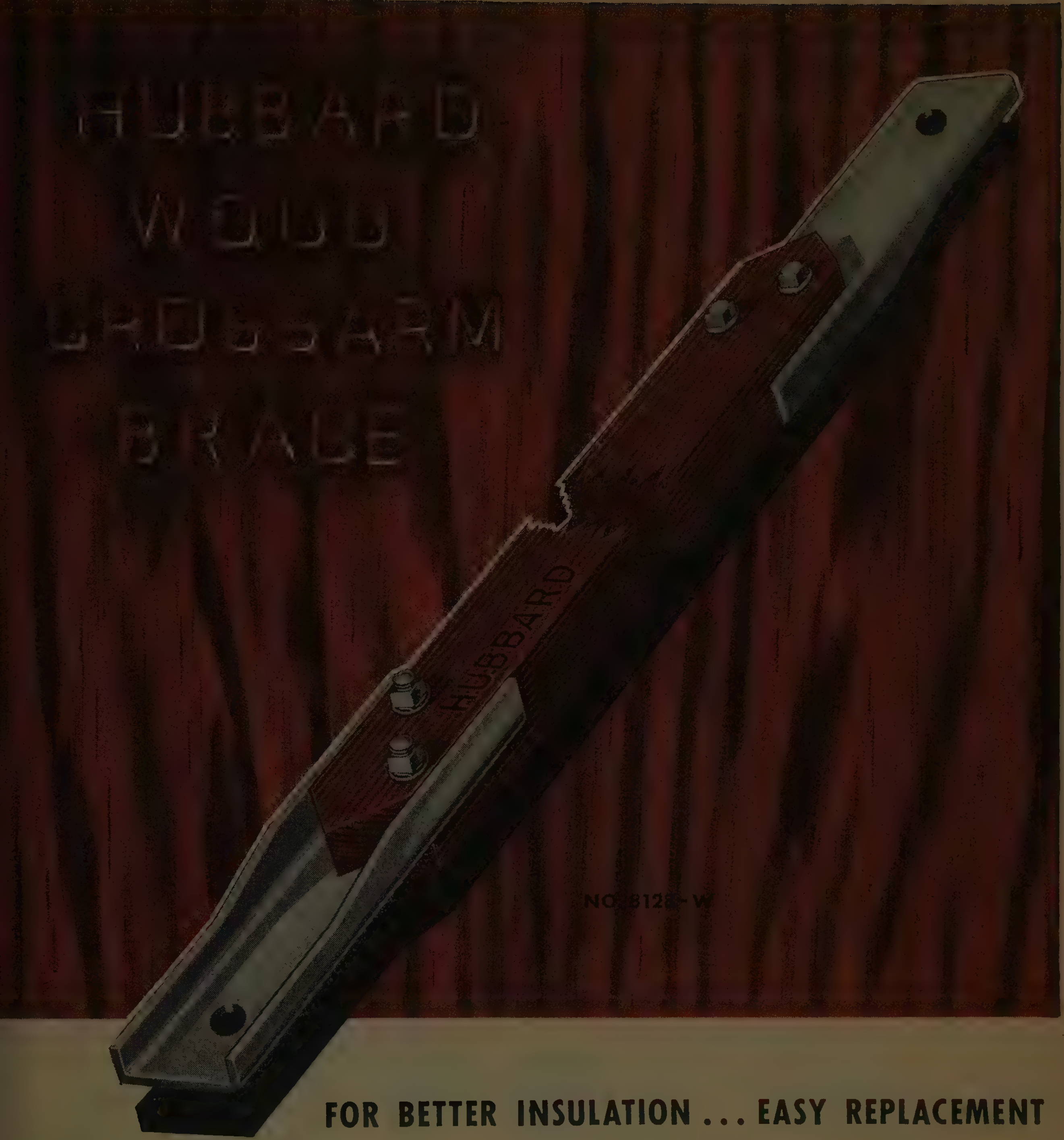
4-51

ELECTRIC POWER DISTRIBUTION FOR INDUSTRIAL PLANTS

This report, S-3, outlines engineering principles in the design of electric power distribution systems for industrial plants and in the selection of equipment for these systems, from the point of entry of the power company service or the plant generating bus to the terminals of the utilization devices. Price $1.00—no discounts allowed. Address:

AIEE ORDER DEPARTMENT
33 West 39th Street
New York 18, N. Y.

4-51



FOR BETTER INSULATION ... EASY REPLACEMENT

e Hubbard No. 8128-W Brace makes it possible to place a standard 28-inch Steel Brace with a Wood ace, without drilling new holes or otherwise altering structure. It is designed as a means of increasing impulse insulation level of medium voltage lines. ese Braces may be used singly or in pairs. High ength in compression, as well as tension, is an out- nding feature of this Brace. The Wood Section is 1-inch by 1½-inches, creosote dipped hickory. The channel steel sections are reversed at the ends to permit installation with the flat side of the channels against the crossarm and the pole. Stock No. 8128-W covers a pair of Braces. Braces are interchangeable—there are no lefts nor rights—therefore, even though Braces are ordered and shipped in pairs, they may be used singly. Metal fittings double-dip, hot galvanized.

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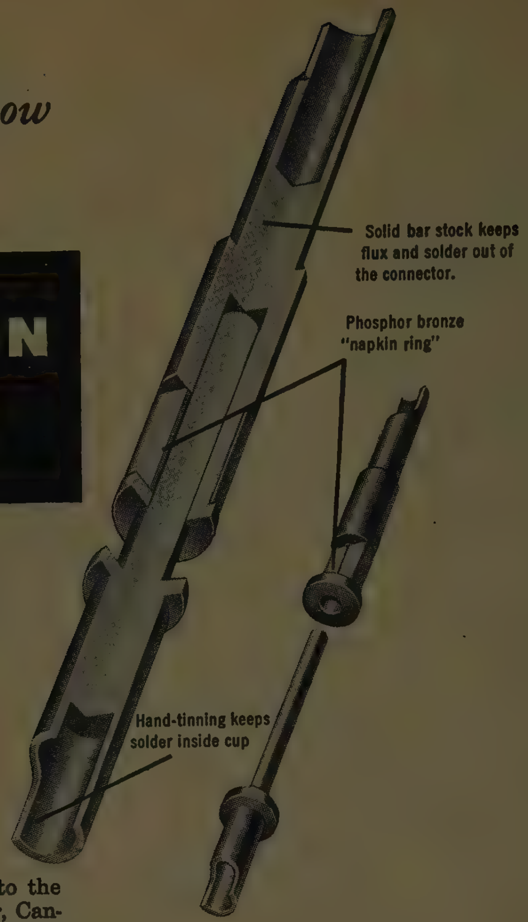
"Hang the Load on Hubbard Hardware!"

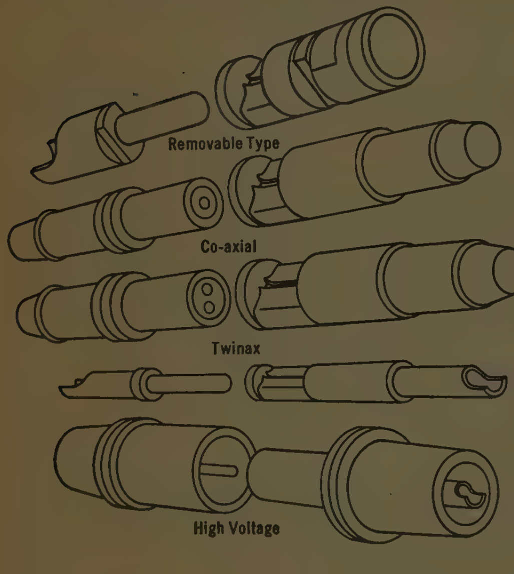
Here's why those in the know demand–

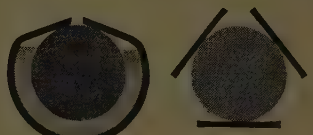
CANNON PLUGS

superior contact design


Solid bar stock keeps flux and solder out of the connector.
Phosphor bronze "napkin ring"
Hand-tinning keeps solder inside cup

Because the contact is the key to the success of any electric connector, Cannon has always applied the highest order of skill and care to this all-important detail. Cannon pin and socket contacts are all precision machined from solid bar stock. Silver or gold plating maintains high conductivity after years of constant use. Phosphor bronze "napkin ring" of the socket keeps pressure on large areas of heavy metal, preventing current loss. There are no thin metal tangent contact points in Cannon contacts. (See below). Solder cups are carefully tinned by hand to keep the solder inside the cup. Cannon socket contacts are full floating to assure perfect alignment. You'll find these design features throughout the great variety of precision contacts used in all Cannon connectors. For real value demand Cannon.





Cannon design (above left) makes contact on large, heavy metal surfaces. Current is not carried through spring section. In Cannon Connectors there are no thin metal tangent contact points, like the design shown at right.

CANNON ELECTRIC

Since 1915

LOS ANGELES 31, CALIFORNIA
REPRESENTATIVES IN
PRINCIPAL CITIES

In Canada & British Empire: Cannon Electric Co., Ltd., Toronto 13, Ontario. World Export (Excepting British Empire): Frazar & Hansen, 301 Clay St., San Francisco, California.

(*Continued from page 28A*)

repeaters or trunk lines having duplex E and M signaling leads. This gives th same type of operation as modern carri telephone systems with integral dialir features. It operates from existing 2 and 130-volt office batteries, or fro conventional a-c power supplies. Oth details are available from the corporatic at 100 Kingsland Road, Clifton, N. J.

Two-Pen Electronic Recorder. Th Leeds and Northrup Company, 49 Stenton Avenue, Philadelphia 44, Pa., h developed a 2-pen Speedomax electron recorder which records two functio simultaneously against time. The instru ment saves tedious compilation and poin by-point plotting of data. Both functio are drawn as continuous curves on $9^7/_8$-inch wide chart. Two separate ele tronically amplified measuring circuit two balancing motors, and two recordir pens are all housed in one standard cas Circuits can be supplied to work wi thermocouples, thermohms, strain gauge tachometers, thermal converters, *p*H cell or other primary elements. The instru ment can operate controls or alarm Speed of response for full-scale pen mov ment is three, two, or one seconds, specified. Chart speed—the *Y* or tim axis—can be selected in the range of 1 1,800 inches per hour. To aid in iden fication, the instrument draws one cur in red ink, the other in black. F full details, write to the company.

Fireye. The Fireye Corporation h introduced a new fire detector, typ *FD-10*, which provides complete covera throughout a room or fire zone witho depending on heat, smoke, or oth indications which result from the presen of fire. Capable of detecting even a ve small fire, this instrument yet will igno extraneous light of any intensity. Actual based on the photoelectric principle, t Fireye protection block provides covera up to 10,000 square feet, by means of PbS infrared photocells, and a contr panel. The supply voltage is 115/230 vo 50/60 cycles and six volts, alternating direct, at two amperes. Additional i formation may be obtained from T Fireye Corporation, 77 Broadway, Ca bridge 42, Mass.

Bronze Power Connectors. Two ser of 2-bolt 1-piece line clamps, whi compensate or flex as the conductor i creases or decreases with the rise and f of conductor and/or ambient temperatu have been announced by the Anders Brass Works, Inc., Post Office Draw 2151, Birmingham 1, Ala. Both ser result from a long study of integrating t proper copper base alloy and connec design into a resulting connecting dev which will maintain a constant high pr sure upon the conductor sufficient to s out the formation of high-resistance oxi on contact areas and to insure pro

(*Continued on page 42A*)

3

Vhen the sector conductors are insulated and shielded, they go hrough this closing die—along with the paper filler strips. Special ies and guides are used to assure that each component is *exactly* n place.

4

After the cable is assembled, it goes to the saturating tank where it is heated under very high vacuum. Certain high-voltage cables are also "washed" with bone-dry carbon-dioxide to remove every trace of moisture. Then, impregnating compound is pumped in until cable is thoroughly saturated.

ONGER, TROUBLE-FREE LIFE INTO

Paper Insulated Cables

This step by step picture trip through our mill tells the story

U·S·S American Paper Insulated Cables are well known for their long, maintenance-free service life. Lots of people have wondered how we make them that way. This picture-trip shows some of the highlights in our carefully-controlled manufacturing process.

AMERICAN STEEL & WIRE COMPANY, GENERAL OFFICES: CLEVELAND, OHIO
COLUMBIA STEEL COMPANY, SAN FRANCISCO, PACIFIC COAST DISTRIBUTORS
TENNESSEE COAL, IRON & RAILROAD COMPANY, BIRMINGHAM, SOUTHERN DISTRIBUTORS
UNITED STATES STEEL EXPORT COMPANY, NEW YORK

USS TRADE MARK

American Electrical Wire & Cable

UNITED STATES STEEL

Standard works with electrical engineers to create specific designs

THE Standard TRADE MARK ®

TRANSFORMER COMPANY
AT YOUR SERVICE

Save time on your engineering projects by using the services of STANDARD'S experienced engineers to detail transformer requirements. Call your nearest STANDARD representative for information on this useful service.

DESIGNING

Specifying transformers for electric systems or equipment is a routine of STANDARD'S staff. Design engineering of special transformers for specific functions is a service our men are particularly qualified to render. Years of this specialized experience will save time and eliminate experimentation.

MANUFACTURING

Manufacturing of STANDARD'S transformers is conducted under the eyes of the designing engineers. A more than usual amount of handwork is practiced in the STANDARD factory to assure better quality. Only craftsmen of rated experience are assigned to critical tasks.

TYPES OF TRANSFORMERS

POWER ● DISTRIBUTION ● INSTRUMENT
STREET LIGHTING ● TESTING
OIL, ASKAREL OR AIR COOLED

THE STANDARD TRANSFORMER CO.
WARREN · OHIO
(EXCLUSIVELY TRANSFORMER DESIGNERS AND MANUFACTURERS)

(*Continued from page 34A*)

distribution of current in conductor strand through to the core wire. Both series ar known as *K* and *KR* line clamps. The differ only in one respect: type *K* incorporates a spacer bar and type does not. Type *K* is adequate for mos applications. However, type *KR*, becaus of the spacer bar, provides better curren distribution among the strands and thereb provides higher conductor utilization an circuit security, especially when faul currents are severe. Seven sizes in eac series cover the range of connecting Number-4 or a 1,000,000-circular-mil mai to a Number-8 or 1,000,000-circular-mi tap. Additional details may be obtaine from the Anderson Brass Company upo request.

Phase Converters. The Ford Instrumen Company, a division of The Sperry Corporation, has produced a new phase converter which converts a primary 4-phas supply for multiphase telemetering equipment. It is a nonrotating unit wit movable primary for initial setting. Th outside shell is anodized to insure corrosio protection. Any further information available from the Ford Instrument Company, Division of the Sperry Corporatio 31–10 Thomson Avenue, Long Island Cit 1, N. Y.

Radio Interference Locator. The Spragu model *302* radio interference locator ha been designed to meet the needs of electri utilities and others interested in radi noise location and reduction. The hea of the instrument is a sensitive 8-tub superheterodyne receiver which receiv signals and permits interference analys over the spectrum from 550 kc to 3 megacycles. Four tuning ranges are provided: 550 to 1,600 kc; 1.5 to 4.4 megacycles; 4.5 to 11.5 megacycles; and 1 to 30 megacycles. Locator sensitivity better than five microvolts in the broadca band and better than two microvolts in a other ranges. Both radio-frequency sensitivity and audio gain controls are calibrate to permit duplication of instrument settin when rechecking interference levels. Consequently, the locator may also be cal brated with a standard signal generato using the radio-frequency input jack, an will serve as an accurate field-streng meter. The locator will operate from th self-contained standard radio battery pa or from any 115-volt a-c or d-c power lin Any further information may be obtain from the Sprague Electric Compan North Adams, Mass.

Tungsten Electrode. A new tungst electrode which will reduce inert-a welding costs has been announced by th General Electric Company's Welding Di sions, Fitchburg, Mass. Major applicatio of the new tungsten will be for inert-a welding with direct current, straig polarity, using either argon or helium g This type is usually used to weld mi steel, stainless steel, copper, and allo The new Hi-Thoria electrodes will produ a stable arc over a wider range of curre

(*Continued on page 48A*)

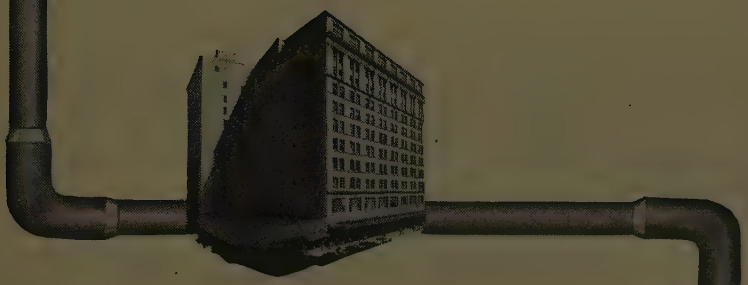
PULLING

Hi ROCKBESTOS A.V.C.

INTO THE OLD CONDUIT

INCREASED CAPACITY

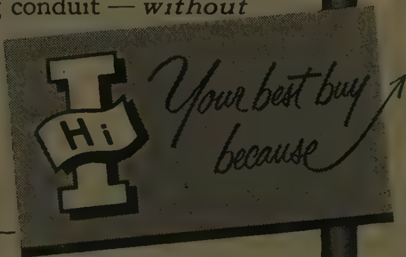
FROM 320 TO 470 AMPS.



G. Fox & Company, Connecticut's largest department store, had a problem. Their building was modern — attractive. However, the electrical distribution system was sized for 1920 loads — couldn't handle the heavy demands of modern lighting, escalators, etc.

The Solution — Rockbestos A.V.C.! Because Rockbestos A.V.C. carries more current size for size than ordinary cable, it offered an ideal solution. They pulled out the old cable — pulled Rockbestos A.V.C. into the old conduits. Capacity was increased 50% *without* replacing conduit — *without* major building repairs — *without* disorganization of selling areas.

Rockbestos A.V.C. is the answer whenever overload circuits are a problem. Write for "Rx for a Building with Hardening of the Arteries."



- **You Use Existing Conduits** yet increase capacity 30 to 50%.
- **You Avoid Building Repairs** such as the bracing, replastering, repainting, normally required for major electrical alterations.
- **You Save Time** because A.V.C. can be pulled into place *fast*.
- **You Avoid Business Interruptions** since rewiring with A.V.C. in existing conduits is clean and easy.

ROCKBESTOS PRODUCTS CORP.
NEW HAVEN 4, CONNECTICUT
New York • Cleveland • Chicago • Detroit
Pittsburgh • St. Louis • New Orleans • Los Angeles
Oakland, Calif.

GREATER DISTRIBUTION SYSTEM *Security*

WITH NEW ONE PIECE K-90 AND K-900 CONNECTORS

EASY AS A B C TO INSTALL

• Completed Trouble Free Positive Connection

For

GREATER STRENGTH: — Compresses conductor sealing out high resistance oxide formations on contact areas.

GREATER EFFICIENCY:—Retains high pressure contacts during vibration and temperature changes.

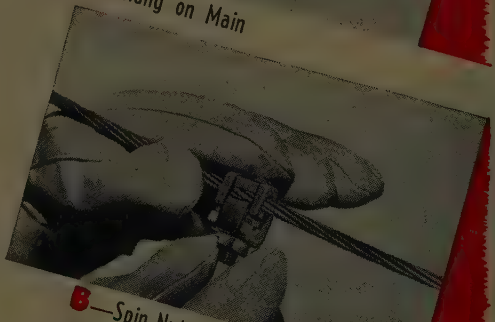
GREATER DEPENDABILITY: —Surpasses Mercurous Nitrate Specification ABW 124-1*, insures against seasonal and stress corrosion cracking failures.

GREATER ECONOMY: — Lower installation cost, four sizes for connections up to 500 MCM.

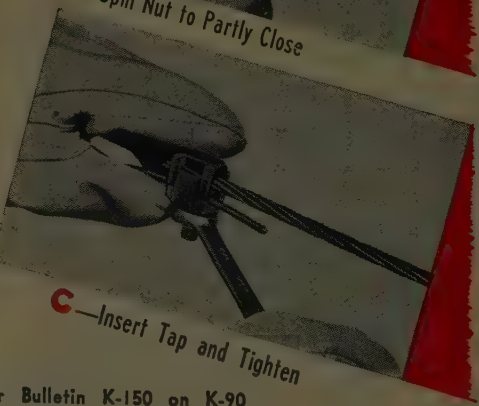
GREATER FLEXIBILITY: — Taps, splices and dead ends easily completed with gloves or hot line tools.

* Identical to ASTM B-154-45 Mercurous Nitrate Specification except ABW-124-1 specifies stressed components which is a more severe test.

A—Hang on Main



B—Spin Nut to Partly Close



C—Insert Tap and Tighten

Consult one of our nearest 19 representatives or contact our main office.

ABW

Write today for Bulletin K-150 on K-90 and K-900 Distribution Connectors.

Anderson Brass Works, Inc.
POST OFFICE DRAWER 2151
Birmingham, 1, Alabama

• BRONZE AND ALUMINUM POWER CONNECTORS, FITTINGS, AND BUS SUPPORTS
ALUMINUM SUSPENSION AND STRAIN CLAMPS

(*Continued from page 42A*)

and will resist contamination by we metal. Strength is comparable to standa pure tungsten. The end of a standa tungsten electrode when subjected to a temperatures tends to become molten a forms a round shiny surface. The molt surface sputters off into the work in rel tively large quantities on arc starting a in minute quantities from time to tim when welding, so that the tungsten slowly consumed. Hi-Thoria tungste however, runs cooler than standard tung ten, and does not become molten. Th end remains square and intact and co sumption is reduced. The arc tends stay under the electrode and will n wander or climb up the electrode at lo currents. Touch starting can be accom plished with currents as low as five ampere Hi-Thoria tungsten is not recommended a standard tungsten replacement f reverse polarity direct current, a-c weldin or atomic-hydrogen welding. Furthe information is available from the Weldin Divisions of General Electric.

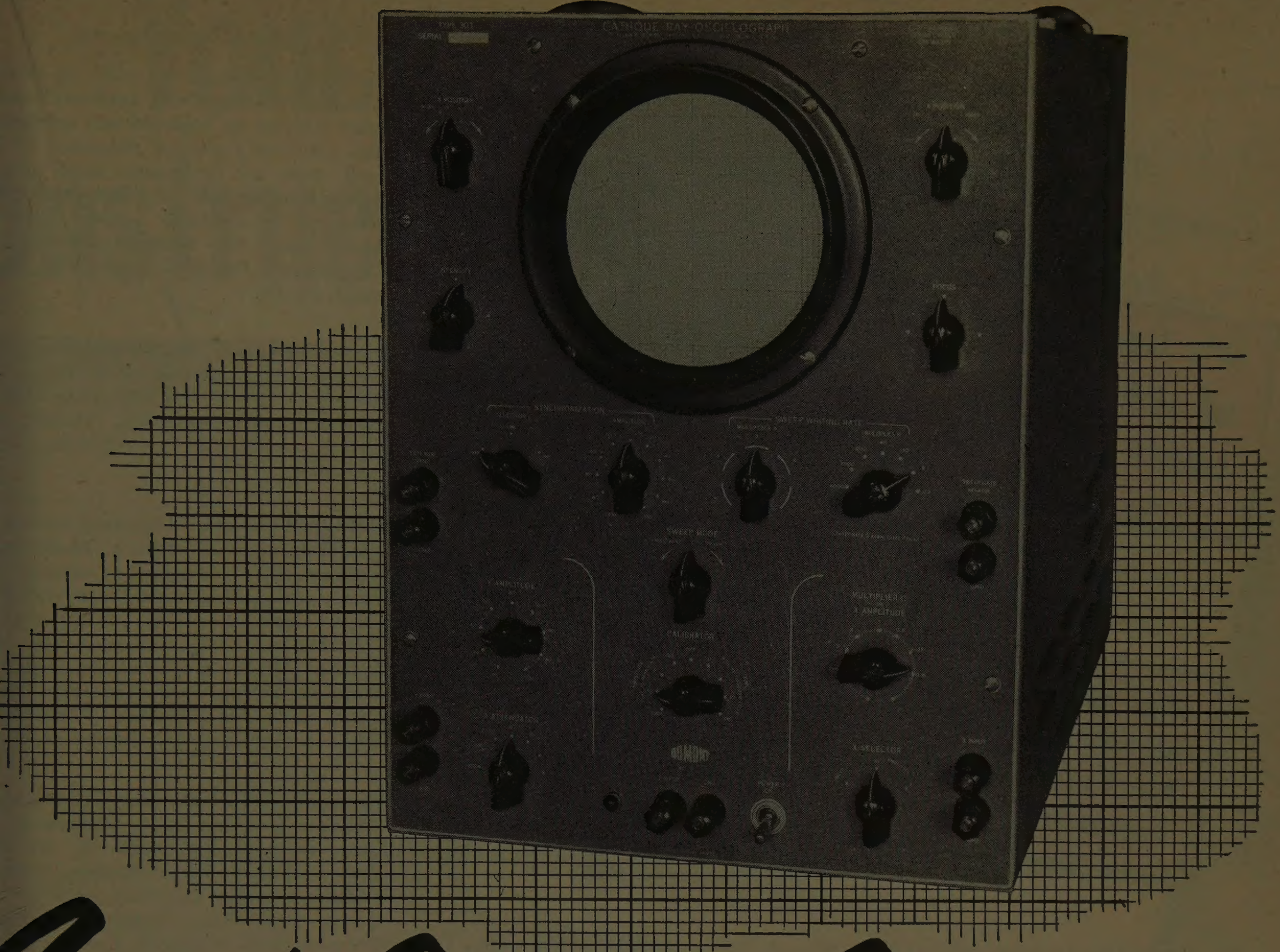
TRADE LITERATUR

Instruments and Research. The accel eration of research through the use industrial and related instruments an apparatus is the subject of an 84-page boo just published by the Brown Instrument Division of the Minneapolis-Honeywe Regulator Company. Entitled "Instru ments Accelerate Research," the boo describes analytical apparatus, such a spectrometers, robotized polarograph titrators and stills, and continuous ga analyzers; precision laboratory measurin instruments such as high-vacuum gauge and pressure and force transducers; an research apparatus components. Copies "Instruments Accelerate Research," bull tin *15–14*, are available at no charge t engineering schools, colleges, and for r search training programs. Address r quests to the Minneapolis-Honeywell Regu tor Company, Industrial Division, Phila delphia 44, Pa.

Manual of Watt-hour Meters. A ne "Manual of Watthour Meters" whic covers the fundamentals of a-c meterin has been issued by General Electric Meter and Instrument Divisions. The 4 page brochure shows how electric energy measured; describes the operating prin ciples of a-c watt-hour meters; an explains the techniques involved in th use, testing, and maintenance of meter This bulletin, *GET-1840*, is available upo request from the General Electric Con pany, Apparatus Department, Schene tady 5, N. Y.

A-C Electric Systems for Aircraft. A sistance to operators and designers of larg aircraft a-c systems is offered by th Westinghouse Electric Corporation in new 70-page book, "Alternating Curren

(*Continued on page 50A*)



xceeds Everyone's Expectations

by outperforming its own specifications...

Read the specifications of the Type 303 and you'll call it a 10-megacycle, quantitative instrument: operate the Type 303 and you'll realize you've sold it short. You'll find performance beyond the exacting limits of its specifications!

An exceptionally fine, medium-priced cathode-ray oscillograph, the Type 303 employs the new Type 5YP- Cathode-ray Tube. High sensitivity and an unusually wide range of sweep speeds make the Type 303 especially well suited for the study of high-frequency phenomena.

Using the equivalent of five inches of undistorted deflection on the Y axis, and six times full-screen expansion on the X axis, qualitative analyses can be highly detailed with the Type 303. Time and amplitude calibration add quantitative precision to this analysis, making the performance of the Type 303 unrivaled in the medium-price field.

Specifications

CATHODE-RAY TUBE — Type 5YP-

Y AXIS:

Sensitivity — 0.1 peak-to-peak volt per inch (down 30% at 10 cycles per second and 10 mc.) down 50% at 15 mc.

Pulse Rise Time — 0.03 microsecond.

Available Undistorted Deflection — 5" for symetrical signals and 2½" for unidirectional signals.

Signal Delay — Sufficient to allow for sweep-starting time.

X AXIS:

Sensitivity — 0.35 peak-to-peak volt/in. (flat to d-c down 30% at 500 kc).

Available Undistorted Deflection — 5"

SWEEP SPEEDS — up to 6" /μsec, obtained by expansion.

SWEEP DURATION — Continuously variable from 0.1 sec. to 2 μsecs. Driven or Recurrent operation.

VOLTAGE CALIBRATION — Square wave with peak-to-peak amplitudes of 0.1, 1, 10, and 100 volts. Accuracy ± 5%.

TIME CALIBRATION — Pulsed oscillations corresponding to time intervals of 100, 10, 1, or 0.1 μsec. Accuracy better than ± 3%.

INTENSITY MODULATION — 15 volts peak will blank the beam.

DuMont for Oscillography

INSTRUMENT DIVISION • ALLEN B. DU MONT LABORATORIES, INC., 1000 MAIN AVENUE, CLIFTON, N. J.

it's because of what you can't see here . .
that makes Pinco Multi-Part, High Voltage, Pin Types Perform better HERE . . .

Everyone knows how Pinco Wet Plastic Process Porcelain gives Pinco 2- and 3-part Pin Types unexcelled insulating qualities . . . how Pinco design provides husky sections and beaded edges to eliminate mechanical failure. But it's the built-in features (exclusive manufacturing techniques) not apparent to the eye in the completed unit, that provide those "plus" values so essential to RIGHT ON THE JOB performance.

What are some of these "plus" values? . . .

1. Pinco resilient compounds, applied to the porcelain surfaces in contact with cement, completely relieve the effects of thermal expansion at any temperature encountered in service.
2. Pinco cementing processes involve laboratory-controlled mixing techniques, and curing in special rooms where temperature and humidity are rigidly regulated.
3. Porcelain sand grains are of uniform size and are applied in belts of even thickness and width.

These are some of the reasons why "right-on-the job" specifiers and buyers are selecting Pinco Multi-Part, High Voltage Pin Types to insure RIGHT ON THE JOB performance.

See page 38, Pinco Catalog No. 49
for complete electrical and mechanical characteristics.

The Porcelain Insulator Corporation
763 Main St., Lima, N. Y.
Sales Agents: JOSLYN MFG. & SUPPLY CO.
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★ PINCO INSULATORS ★

Suspension Insulators . . . Switch and Bus Insulators . . . Distribution Clamps . . . Distribution Pin Types and Guy Strains . . . Transmission Line Fittings . . . Tree Insulators . . . Transformer and Circuit Breaker Bushings . . . One Piece and Multi-part High Voltage Pin Types . . . Suspension and Strain Clamps . . . Indoor Bus Support Porcelain . . . Lightning Arrester Porcelain.

(*Continued from page 48A*)

Electrical Systems for Aircraft" (*R-1064-A*). The book stresses special application problems inherent in high-altitude operations, and provides a general discussion of aircraft type a-c generators and motors, driving mechanisms, and distribution systems. It is available for the price of $1.50 from the Westinghouse Electric Corporation, Post Office Box 2099, Pittsburgh 30, Pa.

Aluminized Steel. Aluminized steel—steel with a special coating of aluminum—is discussed in a new booklet published by the Armco Steel Corporation, Middletown, Ohio. Copies may be obtained upon request.

Industrial Control. Industrial control for temperature, flow, pressure, liquid level, and humidity, is described in catalog *8304*, issued by the Minneapolis-Honeywell Regulator Company. This 60-page catalog presents over 100 nonindicating controllers. Copies are available from the Minneapolis-Honeywell Regulator Company, Industrial Division, Wayne and Windrim Avenues, Philadelphia 44, Pa.

Pressure Terminals and Connectors. Pressure terminals and connectors for every type of application on all wire sizes are listed in a 40-page Sta-Kon Bulletin, number *61*, which may be obtained from The Thomas and Betts Company, Elizabeth 1, N. J.

Electronic Components. A 42-page electronic components catalog, *RC-8*, has been issued by the Electronic Components Division, Stackpole Carbon Company, St. Marys, Pa. It is available upon request.

Production Control. "Production Control in Manufacturing Industries" offers a remedy for bottlenecks in production before they become acute. Requests for the 40-page booklet, *TM-596*, should be addressed to Management Controls Division, Remington Rand, Inc., 315 Fourth Avenue, New York 10, N. Y.

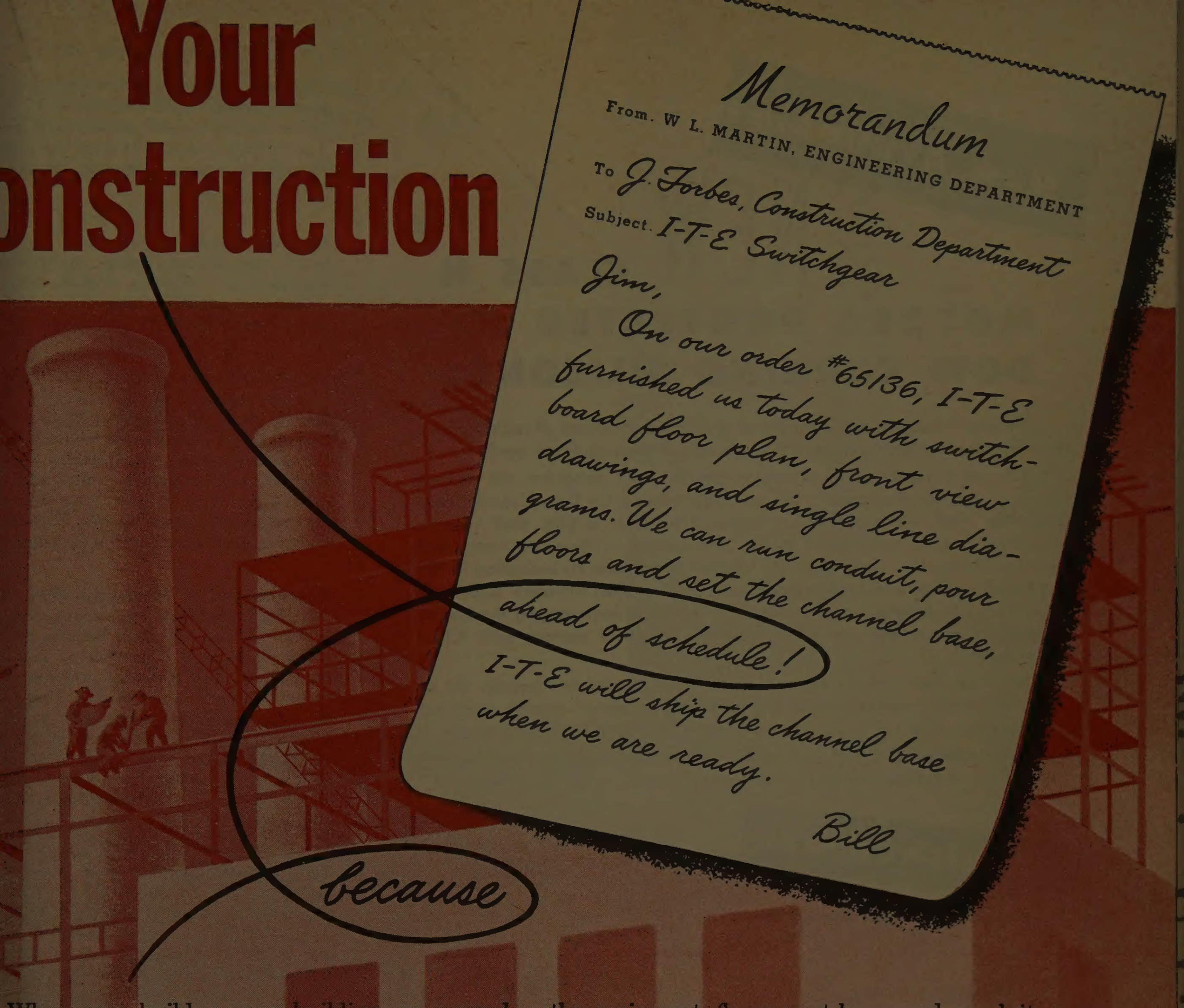
Laminated Plastics. The Taylor Fibre Company has announced publication of its new 1951 catalog, "Taylor Laminated Plastics." The catalog may be obtained upon request to the company at Norristown, Pa.

Abolite Lighting. Industrial lighting equipment manufactured by Jones Meta Products, Inc., is described in their new Abolite catalog and handbook, which may be obtained by writing to the company i West Lafayette, Ohio.

Electric Bushing Standardization. A new standardization program, which replaces more than 1,000 different types o transformer and circuit-breaker bushing with only 38 standard bushings of maximum usefulness, has been described i General Electric's bulletin *GEC-715*. Th

(*Continued on page 56A*)

Your
onstruction



Memorandum

From. W L. MARTIN, ENGINEERING DEPARTMENT

To J. Forbes, Construction Department

Subject. I-T-E Switchgear

Jim,

On our order #65136, I-T-E furnished us today with switchboard floor plan, front view drawings, and single line diagrams. We can run conduit, pour floors and set the channel base, ahead of schedule!

I-T-E will ship the channel base when we are ready.

Bill

When you build a new building or expand existing facilities, you must have perfect timing in coordinating construction schedules. For example, early in your construction planning you need basic drawings. Naturally, many of these drawings come from your suppliers. If they are tardy, you may have trouble meeting construction schedules.

At I-T-E we take a real interest in the solution of this customer problem. When you buy an I-T-E switchboard or unit substation, your order is placed well in advance of the shipping date. But we know that before you can install the equipment, floors must be poured, conduits provided for, and the channel base grouted in place. To do these things, you need certain switchgear drawings, and if you are like most of our customers, you want them quickly. Consequently, when your order is placed with I-T-E, the drawings you need quickly are prepared promptly. Result: you can complete your floor, spot your conduit and set in your channel base *on or ahead of construction schedules.*

—another reason why I-T-E is your best switchgear buy!

For further information on I-T-E Multumite Switchgear contact your local I-T-E representative or write to the I-T-E General Office.

For *more dependable* Switchgear

—specify I-T-E!

R&IE

I-T-E Circuit Breaker Company • 19th & Hamilton Streets • Philadelphia 30, Pa.
Power Switching Equipment: Railway and Industrial Engineering Co., Greensburg, Pa.
Canadian Mfg. & Sales: Eastern Power Devices, Ltd., Toronto • Export Sales: Philips Export Corp., New York

SWITCHGEAR • UNIT SUBSTATIONS • ISOLATED PHASE BUS STRUCTURES • CIRCUIT BREAKERS • MECHANICAL RECTIFIERS • RESISTORS • SPECIAL PRODUCTS

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NEW CLASS H*
MOTORS PROTECTED BY
DOW CORNING SILICONES

. . . the insulation that has already saved industry millions of maintenance dollars plus the hourly output of hundreds of thousands of men!

This most timely announcement caps the test program we started 8 years ago when silicone resins were introduced by Dow Corning Corporation. First we proved by accelerated life testing that silicone insulated motors had a good 10 to 1 advantage in life expectancy and wet insulation resistance. Then we sold silicone (Class H) insulation to the manufacturers of electrical equipment ranging from lift truck and traction motors to solenoid and brake coils. We also encouraged the better rewind shops to rebuild hard working industrial motors with Class H insulation.

Now we can proudly refer American industry to this goodly list of electrical manufacturers, all able and willing to supply electric machines protected by Class H insulation made with Dow Corning Silicones.

Take your special problems to the application engineer representing any of these companies or to our Product Development Engineers.

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ALLIS-CHALMERS MANUFACTURING COMPANY
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THE B·A·WESCHE ELECTRIC COMPANY
WELCO
KURZ & ROOT COMPANY
(INCORPORATED)
WESTINGHOUSE ELECTRIC CORPORATION
THE MASTER ELECTRIC COMPANY

* "Class H" insulation is the kind of insulation that keeps motors running in spite of "Hell and High water." (slanguage dictionary)

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(*Continued from page 50A*)

standard bushings include transformer and circuit-breaker types rated from 15 kv to 230 kv inclusive, 1,200 amperes and below. The bulletin is available from the General Electric Company, Apparatus Department, Schenectady 5, N. Y.

Railroad Radio. The new type *FE* heavy-duty railroad radio equipment is described in a bulletin, *B-4748*, which is available from the Westinghouse Electric Corporation, Box 2099, Pittsburgh 30, Pa.

Industrial Demineralizers. The Penfield Manufacturing Company, Inc., 19 High School Avenue, Meriden, Conn., has issued a folio on their water demineralizers. It contains specification sheets for all Penfield Ion exchange units and demineralized water. The folio may be obtained upon request to Mr. Edward H. Clohessy, general manager of the company.

Regeneration of Insulating Oils. The Sharples Corporation has announced publication of their technical bulletin *50-DO*, which contains a discussion of the contaminating effect of sludge, moisture, and carbonized particles on insulating oils, and the centrifugal equipment used to bring up the dielectric strength of such contaminated oils. This study may be obtained by writing to The Sharples Corporation, 2300 Westmoreland Street, Philadelphia 40, Pa.

Relays and Switches for Industrial Control. The Automatic Electric Company, 1033 West Van Buren Street, Chicago 7, Ill., has issued a new 88-page catalog and technical guide covering its "Relays and Switches for Industrial Control." The catalog will be supplied upon request.

Megger Ground Testers. A new bulletin on megger ground resistance and earth resistivity measuring instruments has been published by the James G. Biddle Company. Copies of the bulletin, *25–7*, will be sent upon request to the company at 1316 Arch Street, Philadelphia, 7, Pa.

Tubes. A revised and enlarged edition of the RCA booklet, "Phototubes, Cathode-Ray, and Special Tubes," *CRPS-102-A*, has been announced by the RCA Tube Department of RCA Victor Division of the Radio Corporation of America. Designed for users in industrial, broadcast, experimental, and similar fields, the new booklet provides technical data on more than 150 RCA electron tubes, as well as spectral sensitivity curves for all phototubes. It is available from RCA tube distributors.

Pyrometer Equipment. New pyrometer equipment, which offers accurate temperature indication, close temperature control of industrial processes, and protection for furnaces, ovens, and kilns, has been described in bulletin *GEA-5534* which is available from the General Electric Company, Apparatus News Bureau, Schenectady 5, N. Y.